State of New York—Department of Agriculture

TWENTY-SEVENTH ANNUAL REPORT

OF THE

BOARD OF CONTROL

OF THE

NEW YORK

Agricultural Experiment Station

(GENEVA, ONTARIO COUNTY)

FOR THE YEAR 1908

With Reports of Director and Other Officers

TRANSMITTED TO THE LEGISLATURE JANUARY 15, 1909

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STATE OF NEW YORK

No. 29.

IN ASSEMBLY,

JANUARY 15, 1909.

TWENTY-SEVENTH ANNUAL REPORT

OF THE

BOARD OF CONTROL OF THE NEW YORK AGRICULTURAL EXPERIMENT STATION

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,

ALBANY, *January* 15, 1909.

To the Assembly of the State of New York:

I have the honor to submit herewith the Twenty-seventh Annual Report of the Director and Board of Managers of the New York Agricultural Experiment Station at Geneva, N. Y., in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,

R. A. PEARSON,

Commissioner of Agriculture.

NEW YORK AGRICULTURAL EXPERIMENT STATION,
W. H. JORDAN, *Director.*

GENEVA, N. Y., *January* 12, 1909.

Hon. CHARLES A. WIETING, *Commissioner of Agriculture, Albany, N. Y.*:

DEAR SIR.—I have the honor to transmit herewith the report of the Director of the New York Agricultural Experiment Station for the year 1908.

Yours respectfully,
T. B. WILSON,
President Board of Control.

ORGANIZATION OF THE STATION
1908.

BOARD OF CONTROL.

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ALFRED G. LEWIS, Geneva.
[1] WILLIS G. JOHNSON, New York.

OFFICERS OF THE BOARD.

THOMAS B. WILSON, *President.*

WILLIAM O'HANLON, *Secretary and Treasurer.*

EXECUTIVE COMMITTEE.

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STATION STAFF.

WHITMAN H. JORDAN, Sc.D., LL.D., *Director.*

GEORGE W. CHURCHILL, *Agriculturist and Superintendent of Labor.*
WILLIAM P. WHEELER, *First Assistant (Animal Industry).*
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JOHN G. GROSSENBACHER, PD.B., A.B., *Assistant Botanists.*
LUCIUS L. VAN SLYKE, PH.D., *Chemist.*
ALFRED W. BOSWORTH, B.S.,
ERNEST L. BAKER, B.S., *Associate Chemists.*
ARTHUR W. CLARK, B.S.,
ANTON R. ROSE, B.S.,
MORGAN P. SWEENEY, A.M.,
JAMES T. CUSICK, B.S.,
OTTO MCCREARY, B.S., *Assistant Chemists.*
HARRY A. HARDING, M.S., *Bacteriologist.*
MARTIN J. PRUCHA, PH.B.,
JAMES WILSON, B.S., *Assistant Bacteriologists.*
GEORGE A. SMITH, *Dairy Expert.*
FRANK H. HALL, B.S., *Editor and Librarian.*
PERCIVAL J. PARROTT, M.A., *Entomologist.*
HAROLD E. HODGKISS, B.S.,
WILLIAM J. SCHOENE, B.AGR., *Assistant Entomologists.*
ULYSSES P. HEDRICK, M.S., *Horticulturist.*
[2] NATHANIEL O. BOOTH, B.AGR.,
RICHARD WELLINGTON, B.S.,
MAXWELL J. DORSEY, B.S.,
[3] WM. H. ALDERMAN, B.S.AGR., *Assistant Horticulturists.*
ORRIN M. TAYLOR, *Foreman in Horticulture.*
[4] F. ATWOOD SIRRINE, M.S., *Special Agent.*
[5] JENNIE TERWILLIGER, *Director's Secretary.*
FRANK E. NEWTON,
WILLARD F. PATCHIN,
[6] CORA A. WHITAKER, *Clerks and Stenographers.*
ADIN H. HORTON, *Computer and Mailing Clerk.*
JULIA H. HOEY, *Junior Clerk.*

Address all correspondence, not to individual members of the staff, but to the NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

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[1] Died March 11.
[2] Resigned Nov. 15.
[3] Appointed Aug. 13.
[4] Riverhead, N. Y.
[5] Absent on leave after Oct. 15.
[6] Appointed Dec. 1.

TABLE OF CONTENTS.

PAGE.

Treasurer's Report 1
Director's Report 7
Report of the Department of Bacteriology:
 Inoculation as a factor in growing alfalfa 27
 The bacterial flora of cheddar cheese 48
Report of the Department of Botany:
 Investigations on some fruit diseases 123
 The Sporotrichum bud-rot of carnations and the silver top of June grass 140
 Troubles of alfalfa in New York State 172
 Potato-spraying experiments in 1907 244
Report of the Department of Chemistry:
 Methods of paying for milk at cheese factories 273
Report of the Department of Entomology:
 Control of scale in old apple orchards 309
 Screening for the protection of cabbage seed beds 335
 Dipping of nursery stock in the lime-sulphur wash 344
 Control of leaf blister mite in apple orchards 369
 Remedies for San José scale and directions for use 388
Report of the Department of Horticulture:
 Distribution of Station strawberries and raspberries 401
 The relation of weather to the setting of fruit; with blooming data for 866 varieties 410
 Varieties of strawberries, with cultural directions 476
Inspection Work 518
Periodicals reviewed by the Station 521
Meteorological data for 1908 527
Index 539

Twenty-Seventh Annual Report

OF THE

Board of Control of the New York Agricultural Experiment Station.

TREASURER'S REPORT.

GENEVA, N. Y., *October* 1, 1908.

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ending September 30, 1908:

Maintenance Fund — Necessary Expense.

APPROPRIATION 1907–1908.

Receipts.

			Dr.
1907.			
Oct.	1.	To balance on hand	$25 89
		To amount received from Comptroller	20,000 00
			$20,025 89

Expenditures.

	Cr.
By building and repairs	$813 22
By chemical supplies	698 21
By contingent expenses	3,649 81
By feeding stuffs	1,141 80
By fertilizers	102 53
By freight and express	578 06

By furniture and fixtures	$626 41
By heat, light and water	517 67
By labor	14 12
By library	1,089 90
By live stock	16 50
By postage and stationery	1,509 15
By publications	3,506 27
By scientific apparatus	63 83
By seeds, plants and sundry supplies	3,060 38
By tools, implements and machinery	619 82
By traveling expenses	1,924 33
Balance, October 1, 1908	93 88
	$20,025 89

GENERAL EXPENSE — HEAT, LIGHT, WATER, APPARATUS, REPAIRS, ETC.

Receipts.

1907.			*Dr.*
Oct.	1.	To balance on hand	$35 66
		To amount received from Comptroller	4,000 00
			$4,035 66

Expenditures.	*Cr.*
By buildings and repairs	$1,437 95
By contingent expenses	103 60
By freight and express	474 41
By heat, light and water	1,455 31
By scientific apparatus	24 00
By seeds, plants and sundry supplies	6 79
By tools, implements and machinery	238 65
Balance, October 1, 1908	294 95
	$4,035 66

SPECIAL FUND — HORTICULTURAL INVESTIGATIONS.

Receipts.

			Dr.
1907.			
Oct.	1.	To balance on hand	$0 51
		To amount received from Comptroller	8,000 00
			$8,000 51

Expenditures.

	Cr.
By contingent expenses	$646 52
By fertilizers	157 76
By freight and express	1 09
By library	12 20
By postage and stationery	1 20
By publications	376 73
By salaries	5,670 04
By seeds, plants and sundry supplies	67 48
By traveling expenses	985 40
Balance, October 1, 1908	82 09
	$8,000 51

SALARIES.

Receipts.

			Dr.
1907.			
Oct.	1.	To balance on hand	$1,900 33
		To amount received from Comptroller	28,000 00
			$29,900 33

Expenditures.

	Cr.
By salaries	$29,318 35
Balance, October 1, 1908	581 98
	$29,900 33

LABOR.

Receipts.

			Dr.
1907.			
Oct.	1.	To balance on hand	$1,176 45
		To amount received from Comptroller	13,000 00
			14,176 45

Expenditures.

	Cr.
By labor	$13,884 85
Balance, October 1, 1908	291 60
	$14,176 45

FERTILIZER INSPECTION.

Receipts.

			Dr.
1907.			
Oct.	1.	To balance on hand	$7,249 25
		To amount received from Comptroller	7,000 00
			$14,249 25

Expenditures.

	Cr.
By chemical supplies	$1,287 28
By contingent expenses	50
By freight and express	33 31
By heat, light and water	400 00
By postage and stationery	25
By publications	1,021 82
By salaries	7,375 46
By scientific apparatus	97 22
By seeds, plants and sundry supplies	31 40
By traveling expenses	50 26
Balance, October 1, 1908	3,951 75
	$14,249 25

CONCENTRATED FEEDING STUFFS INSPECTION.

Receipts.

		Dr.
1907.		
Oct. 1.	To balance on hand	$609 14
	To amount received from Comptroller	3,500 00
		$4,109 14

Expenditures.	Cr.
By chemical supplies	$179 34
By contingent expenses	25
By freight and express	103 34
By heat, light and water	423 80
By postage and stationery	60
By publications	719 36
By salaries	1,570 00
By traveling expenses	535 30
By balance, October 1, 1908	577 15
	$4,109 14

DWELLING HOUSES.

Receipts, 1907–1908.

	Dr.
To amount received from Comptroller	$95 63

Expenditures.	Cr.
By buildings	$95 63

INSURANCE MONEY.

		Dr.
1907.		
Oct. 1.	To balance on hand	$22 07

		Cr.
1908.		
Oct. 1.	By balance on hand	$22 07

UNITED STATES APPROPRIATIONS.

HATCH FUND.

Receipts, 1907–1908.	*Dr.*
To receipts from the Treasurer of the United States as per appropriation for fiscal year ended June 30, 1908, as per act of Congress approved March 2, 1887	$1,500 00

Expenditures.	*Cr.*
By labor	$700 79
By salaries	799 21
	$1,500 00

ADAMS FUND.

Receipts, 1907–1908.	*Dr.*
To receipts from the Treasurer of the United States as per appropriation for fiscal year ended June 30, 1908	$900 00

Expenditures.	*Cr.*
By salaries	$900 00

All expenditures are supported by vouchers approved by the Auditing Committee of the Board of Control and have been forward to the Comptroller of the State of New York.

(Signed) W. O'HANLON,
Treasurer.

DIRECTOR'S REPORT FOR 1908.*

To the Honorable Board of Control of the New York Agricultural Experiment Station:

GENTLEMEN.— I have the honor to submit herewith a report of the activities of this institution for the year 1908, together with a statement of its condition and needs.

ADMINISTRATION.

STATION STAFF.

It is gratifying to report that the changes in the Station Staff during 1908 were less than for many previous years. In general, continuity of service, especially in scientific inquiry, makes for efficiency of service.

Nathaniel O. Booth, for several years Assistant Horticulturist, severed his connection with the institution on November 15th. During the last few years of Mr. Booth's connection with the institution he devoted his time almost wholly to assisting in the preparation of the publications known as " The Apples of New York " and " The Grapes of New York," in which capacity he rendered highly useful service.

William H. Alderman, B. S. Agr., a graduate of the New York State College of Agriculture, was appointed to the position of Assistant Horticulturist and has entered upon his duties.

MAINTENANCE FUNDS.

The funds availale for the maintenance of the Station during the fiscal year beginning October 1, 1907 were as follows:

Salaries	$28,000	
Labor	13,000	
Expenses of various departments of research	20,000	
General expense, heat, light, water, etc	4,000	
Horticultural investigations	8,000	
Fertilizer inspection	10,000	
Feeding stuffs inspection	3,500	
		$86,500

* A reprint of Bulletin No. 310.

The Legislature of 1908 appropriated the following sums to the uses of the Station for the fiscal year beginning October 1, 1908:

Salaries	$31,000	
Labor	13,000	
Maintenance expenses of departments of research	20,000	
Horticultural investigations	8,000	
General expense, heat, light, water, etc.	4,000	
Fertilizer inspection	10,000	
Feeding stuffs inspection	3,500	
		$89,500

At a recent meeting of your Board it was decided, after a full discussion of the situation, to ask for the following sums with which to carry on the work of the Station during the fiscal year 1909–10:

Salaries	$35,000	
Labor	15,000	
Expenses of various departments of research	25,000	
General expense, heat, light, water, etc.	4,000	
Horticultural investigations	8,000	
		$87,000
Fertilizer inspection	10,000	
Feeding stuffs inspection	3,500	
		13,500
Extra repairs (in Supply Bill)	2,500	
		2,500

In 1905 your Board asked that $25,000 be added to the maintenance funds of the Station. The financial committees of the Legislature did not feel at that time that the resources of the State would justify such an increase of appropriation, and additional sums, amounting in the aggregate to only $10,000, were granted. In 1908 an increase of $3,000 was allowed. It is now desired that the increase originally felt to be necessary shall be fully accomplished.

There are several reasons why this request is reasonable and in accord with the real interests of agriculture. In the first place there has been a constant development of the work of the Station, due not to any forced growth but to the greatly enlarged relations which scientific inquiry and results have come to sustain to practical agriculture. More than this, the general increase in the cost of living has reacted upon salaries and wages and has greatly increased the cost of maintaining an institution.

In the second place, the support the State is giving to investiga-

tion has not kept pace with the aid rendered by the State to other efforts in the interest of agriculture, particularly agricultural education in its various forms and the defense and encouragement of agriculture through a State Department. The following figures make this clear, which refer to appropriations for annual maintenance and not for buildings.

	Agricultural societies.	State society and fair.	State Department.	Agricultural education.	Agricultural investigation.
Appropriations 1896..	$5,,000	$30,000	$119,500	$16,000	$58,000
Appropriations 1908..	250,000	87,650	348,260	180,100	76,000

The sums appropriated to the Station for aiding in the enforcement of inspection laws should not be regarded as used in the work of inquiry.

It is seen that for the enforcement of agricultural law and the encouragement of agriculture in various ways the sum used has trebled or more while the amount applied to agricultural education has come to be nearly two and one-half times that expended in agricultural investigation, increases that are entirely to be commended.

In considering these facts some may argue that the sums applied in the several directions are in proportion to the needs. Such a position can hardly be sustained. The technical work of the agricultural college and school is utterly dependent upon scientific inquiry and without it modern agricultural education would not have been possible. Further progress in our knowledge of the principles of agriculture will come, not from the teacher but from the investigator. Moreover, the administration of law in the interests of agriculture finds an indispensable aid in the studies of the laboratory. But more insistent than all else are the present great unsolved agricultural problems that are facing us in soil management, animal husbandry, fruit production and in the defense of crops against pests and untoward conditions. Agricultural practice is handicapped not alone by ignorance of what is known but also by our limitations of knowledge. We have learned much during the past fifty years but we have scarcely begun the solution of many of our severest and most important problems.

The sum for which your Board is asking is no greater, and in some cases less, than large states like California, Illinois and Ohio

are applying to experiment station work. The extent and complexity of New York agriculture present needs for inquiry equal to, if not greater than, those of any other state.

When it is realized that the agricultural production of New York is worth annually not less than two hundred and fifty millions of dollars and that a saving of one per ct. of this sum through improved methods or the defense of crops against fungus and insect pests, would pay the expense of this institution twenty-five times over, it is easy to realize the actual economy of promoting agricultural knowledge in every possible way.

STATION PUBLICATIONS.

The following figures compiled from the mailing lists now on file at the Station show how the station publications are being distributed:

Popular Bulletins.

Residents of New York	36,055
Residents of other states	2,641
Newspapers	765
Experiment stations and their staffs	1,476
Miscellaneous	115
Total	41,052

Complete Bulletins.

Experiment stations and their staffs	1,476
Libraries, scientists, etc	190
Foreign list	274
Individuals	3,457
Miscellaneous	115
Total	5,512

As the above statement indicates, the Station bulletins are of two general kinds, those that give a complete, and somewhat technical, account of the investigations or experiments and their results and those that present in a form believed to be available to the average reader the facts and conclusions that we reach. In every "popular" bulletin is printed the statement that the "complete" form on which it is based may be had on request. It is significant that in over eleven years those requesting the complete form are considerably less than one-tenth of the number of persons to whom the "popular" bulletins are sent. This indicates that the simpler and

abbreviated statement of our conclusions meets the needs of the great majority of the readers of the bulletins.

Still more significant is the fact that only one copy of a bulletin is distributed in New York for approximately each seven farms. If it could be shown that six out of seven farms do not ask for the bulletins because they have no practical value, it would be a cause for serious reflection on the part of the management of the Station. That this is not the explanation is shown by the fact that a minority of farmers have sought and used to their profit the information that the Station has been able to furnish. It is not the function of the Station to issue merely general education literature and sow it broadcast over the State. To do this would be to misuse the funds assigned to the Station for an entirely different purpose. Fortunately the distribution of bulletins is not a measure of the Station work. Through popular efforts such as farmers' institutes and extension literature and also through the examples set by their more progressive neighbors, thousands of farmers are benefited by the newer phases of knowledge who pay little direct attention to station publications. It is correct to say that only a minority of the farmers of the State attend the State Fair or receive instruction from the college of Agriculture, nevertheless these institutions are exerting strong influence in agricultural affairs.

Besides bulletins distributed during 1908 the Annual Report for 1907 has been prepared in three parts: (I) The report of the work for 1907 including an index of the first twenty-five reports, (II) the Grapes of New York and (III) a review of the work of the Station for twenty-five years, including an account of the twenty-fifth anniversary exercises.

NEW HOUSES.

The five dwelling houses so long contemplated and so long needed are at last completed and are practically ready for acceptance by the State. The method of construction and the quality of work on these buildings appear to be most excellent. The efficiency of inspection by the State Architect and the willingness of the contractors to comply with every reasonable requirement are to be commended.

A BUILDING NEEDED FOR ADMINISTRATIVE AND DEMONSTRATION PURPOSES.

For two years your Board has urged upon the Legislature the need of an audience room at the Station combined with space for permanent objective illustrations of our work. The time has now

come also when the building in which the library and administrative offices are now located, formerly a dwelling house, should be devoted wholly or in part to other purposes. The action of your Board in deciding to continue your efforts for a building of this nature is in accord with the needs of the institution.

The reasons why such a building should be erected are:

(1) There is no place at the institution where an audience can be assembled, excepting out of doors in the pleasant days of the warm season. This is wrong; for the work of the Station stands in such relation to educational interests and farm practice that some way of assembling audiences on the Station ground and bringing them into close range with the Station activities and results should be made possible.

(2) It is extremely desirable that space shall be provided where the results of Station work can be illustrated in a concrete form. We have many visitors who state that they come to see what the Station is doing, not realizing that in the progress of our inquiries they can only see a single point in the progress of an experiment or investigation, which to the untrained eye may be meaningless.

Space is needed for the objective display of results that have been reached in dairy work, in the study of farm pests, field experiments and in other directions. Such a exhibit would be especially useful and instructive in connection with meetings here of horticultural societies and other bodies interested in special lines of production.

(3) The building now used for administrative and library purposes is needed for other uses. It has come to be necessary to arrange for boarding the unmarried members of the staff at some point nearer than the city. Rooms are now available on the Station grounds, but arrangements for meals near the Station are now difficult and uncertain, sometimes impossible. With slight expense the building now used for offices and library could be adapted to the uses indicated and it would be a much needed convenience. Getting a noon lunch a mile or mile and a half away occasions either much loss of time or such haste as is equally detrimental to health and good work.

The contemplated building should contain administrative offices, space for illustrative work and an audience room. It should have not less than 11,000 feet of floor space exclusive of the basement.

REPAIRS.

An extra expense for repairs will be necessary during 1909. Every building on the grounds, exclusive of the new houses, must

be painted, new coverings to roofs must be laid, and the chemical laboratory, which has had practically no repairs for seventeen years needs considerable not only in the way of interior painting but also changes necessary to accommodate our increasing chemical work. It is estimated that $2,500 additional will be needed.

GRADUATE SCHOOL OF AGRICULTURE.

The Graduate School of Agriculture, for which plans were made in 1907, was held at the New York College of Agriculture during the month of July. This school was organized not only in the interests of teachers in our agricultural colleges but for the benefit as well of those who are engaged in agricultural research. The faculty was largely made up from the staffs of the agricultural colleges and experiment stations aided by distinguished teachers and scientists from outside these sources, and the students consisted mostly of the younger men from the same institutions. Six members of the staff of this institution served as teachers and nearly every member of the staff attended the school for a portion of the time.

RELATIONS WITH THE NEW YORK COLLEGE OF AGRICULTURE.

I cannot refrain from expressing my high appreciation of the relations in the way of conference and co-operation that now exist between this institution and the New York State College of Agriculture. The members of the staffs of the two institutions consult one another freely in regard to their work, the facilities of both institutions are shared in common, no scientific jealousies exist and my personal relations to Director Bailey afford me inspiration and valuable counsel. No less gratifying are the relations that have grown up with the State Department of Agriculture through official associations and in other ways. The New York State Grange and the various special agricultural organizations of the State are a direct source of strength to the Station and through their confidence and aid emphasize our obligations to render efficient service to the agriculture of the State.

REVIEW OF THE YEAR'S WORK.

INSPECTION WORK.

Commercial fertilizers.— In November, Bulletin No. 204 was distributed giving the results of analysis of 630 samples of fertilizers

collected by the Commissioner of Agriculture and sent to the Station for examination. The conditions under which fertilizer inspection is carried on do not seem to be fully understood. The administration of the fertilizer law is entirely in the hands of the Commissioner of Agriculture. The guarantees are received and filed by his office and the licenses are issued by him. Cases of violation of the law are referred to the Attorney-General by him. The only part taken by the Station in this inspection is the analysis of the samples collected and the preparation and printing of the bulletin giving the results of the analyses. The brands of goods which the various samples represent are not known by the Station officials. These samples are sent to the Station by number, accompanied by a statement of the guarantees as found on the bag, but without the name either of brand or manufacturer. Nothing is known of what is filed in Albany. After the analyses are all completed and reported to the Commissioner, a statement of the brands and the reported analyses is sent back to me for publication as authorized by law. Anyone wishing information as to guarantees or analyses previous to the publication of the bulletin should apply to the Commissioner of Agriculture and not to the Station, for we are not able to give such information until it is received from the Commissioner of Agriculture.

Concentrated commercial feeding stuffs.—Bulletin No. 303, published in July, gives the analyses of 297 samples of concentrated commercial feeding stuffs, classified as follows:

CLASSIFICATION OF FEEDING STUFFS ANALYZED IN 1908.

Classification.	Number of brands sampled.	Number of samples analyzed.	Number of samples materially below guarantee.
Cottonseed meals	11	20	1
Linseed meals	11	11	1
Gluten feeds	12	12	5
Corn brans	2	2	0
Dried distillers' grains	10	11	0
Malt sprouts	25	26	1
Dried brewers' grains	10	10	0
Hominy feeds	15	16	0
Compounded feeds	96	99	9
Animal products	35	36	6
Poultry foods (compounded)	34	34	1
Beet-sugar wastes	1	1	0
Oat by-products	2	2	1
Barley by-products	2	2	0
Unclassified	13	15	3
Totals	279	297	28

The showing for the inspection of 1907–1908 is very much better than that from 1906–1907. In the former year 69 samples were found to be materially below guarantee, which is practically two and one-half times as many as those reported deficient in this bulletin.

In addition to the analyses required for determining whether the composition of the samples corresponds with the guarantees, special examinations were made of various compounded feeds to discover the nature of the ingredients in the mixtures. Fifty feeds were so examined and in a large majority of cases the presence of inferior materials was clearly evident. The facts were stated in Bulletin 303 essentially as follows:

(1) Nearly all of the compounded feeds examined contain either oat hulls greatly in excess of what belong to the ground oats present, or ground corn cobs.

(2) The molasses feeds, of which there were twelve brands examined, nearly all contained a great variety of weed seeds, some of which are noxious weeds such as mustard, charlock, wild carrot and English plantain (narrow leaved plantain, buckhorn). Germination tests show that in several cases these seeds have not lost the power of germination. For instance, in one sample 50 per ct. of the English plantain seed germinated. It is beyond question possible for these seeds to reach the soil without having lost their germinating power. Moreover, these weed seeds have an unknown nutritive value, and unquestionably many of them having highly resistant coatings pass through the animals undigested. These seeds are, therefore, not only a menace to the land but to the productiveness of the animals that are being fed these molasses feeds on the assumption that they take the place of pure, sound farm grains or of other standard feeding stuffs.

(3) The gluten feeds are found in many instances to contain artificial coloring matter and to have considerable free acid, conditions that are not commendable.

DEPARTMENT OF BACTERIOLOGY.

Inoculation as a factor in growing alfalfa.— The need of inoculation was tested in 67 fields distributed among 33 counties of this State. The bacteria, *Ps. radicicola,* which enable alfalfa to obtain nitrogen from the air were present, at least in small numbers, in practically all of the 67 experimental fields. However, it was only in one-third of the fields that they were present in sufficient numbers

to produce an inoculation in any considerable number of young alfalfa plants.

An attempt to supply the ferms by applying pure cultures of *Ps. radicicola* to the seed, drying and sowing, resulted in almost complete failure, while applying soil from an old alfalfa field at the rate of 150 to 300 pounds per acre invariably produced an abundant inoculation on these experimental fields.

Although but 15 of the 67 experimental plats produced a successful crop of alfalfa without inoculation, 48 of the adjacent plats where inoculating soil had been applied produced successful crops. That it to say, alfalfa growing, on 33 of the 67 fields which were tested, was changed from a failure to a success by the application of inoculating soil. These tests are described in detail in Bulletin No. 300.

The bacterial flora of cheddar cheese.— A quantitative and qualitative study of the bacterial flora has been made during the ripening period in nine normal cheddar cheeses, the work being reported in Technical Bulletin No. 8. There was no evident connection between the number of bacteria present and the rate at which the cheeses ripened. When commercially ripe a cheddar cheese usually contains some millions of living bacteria per gram.

More than 300 pure cultures were isolated and finally reduced to 33 groups according to the classification of the Society of American Bacteriologists. Ten of these groups disappeared from the cheese at once; representatives of nine other groups were found in but single cheeses, although they persisted there for some time; the remaining 14 groups are the most important members of the cheese flora. The *Bacterium lactis acidi* of Leichmann, which includes 4 of these 14 groups, is the only species which was always found and it practically always included over 99 per cent. of the total germ content of the ripening cheese.

DEPARTMENT OF BOTANY.

Potato spraying experiments.— During the season of 1907 the potato spraying experiments begun in 1902 were continued along practically the same lines as in previous years; and the results are reported in Bulletin No. 307. In the ten-year experiment at Geneva five sprayings increased the yield 73.7 bu. per acre, while three spraying increased it 44 bu. In the duplicate of this experiments at Riverhead, Lond Island, the gain due to six sprayings was 31.25 bu. per acre and to three sprayings 18 bu. In fourteen farmers' busi-

ness experiments, including 152.75 acres, the average gain due to spraying was 36.8 bu. per acre; the average total cost of spraying $5.90 per acre; and the average net profit $17.07 per acre. Twenty-four volunteer experimenters reported gains averaging 30.5 bu. per acre.

Thus far the results are highly favorable to the practice of spraying. In the ten-year experiments at Geneva the average gain for six years from spraying every two weeks has been 121.7 bu. per acre, and from spraying three times during the season 93.5 bu. At Riverhead the corresponding gains have been smaller — 60.5 bu. and 32.5 bu. respectively.

In 62 business experiments made in five years the average gain due to spraying has been 49 bu. per acre and the average net profit from spraying $19.86 per acre. In 177 volunteer experiments reported in four years the average gain from spraying was 50.3 bu. per acre.

Alfalfa troubles.— The increasing interest in alfalfa culture in New York seemed to warrant an investigation of the various troubles to which the crop is subject; and this investigation furnished material for Bulletin No. 305. Special attention has been given to dodder, fungus diseases and the impurities and adulteration of seed. The chief difficulty with alfalfa in New York is to get the crop established. Several factors may be concerned in this: Poor seed, sour soil, wet soil, sowing with a nurse crop, lack of nodule bacteria, lack of humus, weeds, leaf spot disease, close cutting and winter injury. Dodder is often a serious pest. It is perennial, not annual as generally believed. Trouble with it is avoided by sowing only dodder-free alfalfa seed. The Station will analyze seed samples free of charge. Dodder seeds may be removed from alfalfa seed by sifting if the proper kind of sieve is used. The most practicable method of eradication is that of burning over the dodder-infested spots. The only important fungus disease is leaf spot. This causes an enormous loss in the aggregate, but seldom ruins the crop completely. The remedy for leaf spot consists in mowing whenever the plants turn yellow and become so badly diseased that their growth is severely checked. The investigation disclosed the existence of several new alfalfa diseases the most important being one called "yellow top," the cause of which was not definitely determined. There are no very important insect enemies of alfalfa in New York.

Sporotrichum bud-rot of carnations.— This disease, previously known only in Nebraska, recently appeared in some New York greenhouses. The Botanist and one of the Assistant Entomologists, working in co-operation, have made a considerable study of it, the investigations being reported in Technical Bulletin No. 7. The cause of the disease was proven to be a fungus, *Sporotrichum poæ* Pk. This fungus is found in the decayed tissue of diseased buds in constant association with a peculiar mite which, apparently, serves as a distributor of the fungus. The mite was identified as *Pediculopsis graminum* Reut, a species heretofore unknown in this country, but in Finland recognized as one of the chief agents in the production of a common grass disease called " Weissährigkeit." June grass in New York is abundantly affected with the same disease which is here known is " silver top." The fungus and mite have been found, frequently associated, on June grass affected with silver top, but their relation to that disease has not been investigated.

DEPARTMENT OF CHEMISTRY.

Methods of paying for milk at cheese-factories.—This subject is one of fundamental importance to dairymen who produce milk for cheese-making. This Station has given the matter more extensive and thorough study than any other institution, having previously published two bulletins (68 and 110) in relation to it. As many as six different methods have been proposed, which may be grouped under the following general divisions: (1) On the basis of the weight of milk; (2) on the basis of milk-fat; and (3) on the basis of the yield of cheese. The first method has been proved beyond all question to be unfair, because milk varies greatly in its cheese producing power. It has been shown that in different milks the yield of cheese from 100 pounds of milk may be as low as 8 pounds and as high as 13 pounds. The yield of cheese might be supposed to furnish a fair basis, but it has been proved that cheese made from milk rich in fat is superior in quality and value to cheese made from milk poorer in fat. When milk is paid for on the basis of its fat content, the yield, composition and quality are all taken into consideration. While a pound of fat in rich milk is equivalent to less cheese than a pound of fat in poorer milk, owing to the somewhat larger relative amount of casein in the latter, the quality of cheese made from richer milk is enough better to make up for this difference in yield in relation to milk-fat. Besides being the most fair basis, when yield and quality of cheese are considered, the

payment according to the milk-fat exercises a most important and direct influence upon the milk producers; because it removes all temptation to skim or water milk, and because it offers a special inducement to produce milk containing larger amounts of milk-fat.

The full discussion of these methods will be found in Bulletin No. 308.

DEPARTMENT OF ENTOMOLOGY.

Control of scale in old apple orchards.—The control of the pest in old apple orchards is the most important phase of the San José scale problem in this State. Realizing the dangers that threatened the apple industry, the Station began a series of co-operative tests to ascertain practical measures for protecting the older trees. These tests were conducted for several years in commercial apple orchards at Youngstown in Niagara County, Geneva in Ontario County and Yorktown in Westchester County; and are reported in Bulletin No. 296. In these experiments the standard remedies were employed for the treatment of the main portions of the orchards, and comparative tests were made of the more promising sprays of recent introduction. The tests have proven clearly that it is possible, without great expense, to protect old trees so thoroughly that the crops are not lessened and that little if any of the fruit shows spotting. Experience, derived from our own experiments and observations on the efforts of commercial fruit growers, demonstrates, with increasing emphasis each year, that the control of the scale on old apple trees is practicable, and that efficient protection can be afforded at at a relatively nominal expense, compared with the returns from a well managed orchard. The cost of spraying apple orchards varies from year to year and with different fruit growers. The principal factors that determine the expense are labor, machinery, size of trees, weather conditions, kind and cost of spraying supplies and general management.

Of the various sprays that have been tested, the sulphur wash and the home-made oil emulsions have, on the basis of efficiency, economy and safety to the trees, proven the most satisfactory remedies. Of the two, the oil emulsions have generally been somewhat more efficient than the sulphur wash in the treatment of old appie trees, and excellent results have been obtained with a light treatment of emulsion on trees previously sprayed with the lime-sulphur wash to reach the scales on the young wood. Either of these sprays singly or the emulsions supplementing an application of the sulphur wash, if thoroughly applied, can be depended on to control the scale,

and are recommended for the treatment of old trees. Miscible oil in the proportions used has prevented important injuries to the trees and has generally proven an efficient remedy for the scale. These preparations of good grade are among the most satisfactory substitutes for orchardists who do not desire to employ home-made mixtures.

Screening for the protection of cabbage seed beds.— This bulletin, No. 301, deals with experiments to test the value of cheesecloth screening for the protection of cabbage seed beds against injuries by root maggots. In most sections of this State where cabbages are raised, the growers experience much difficulty in raising enough seedlings, of required size, to plant the desired acreage, because of the destructiveness of these insects. Of the various measures that have been employed in the experiments with this pest, screening of the plants has afforded the most efficient protection to seed-beds. Because of its efficiency for this purpose, the attention of growers is called in this bulletin to the value of screening of beds as one means of protecting plants from injuries by root-maggots.

In the experiments, four large beds were made, the seed being sown respectively on April 29, May 13, May 17 and May 28. Screening was applied to 21 rows, of 150 feet in length, of the planting of May 13. The remainder of the bed, consisting of 68 rows of equal length, was considered as a check. Plants raised under cloth grew faster and reached the desired size for transplanting one week before the seedlings in the check area. The screened sets were seasoned by the removal of the covering thirteen days before the time of replanting, and showed no more wilting when transplanted than did the check seedlings. The screened bed was entirely free of maggots, and produced 50,000 sets, which were replanted. The check bed, of more than three times the size, yielded only 30,000 desirable plants. The cabbage-maggots were generally very destructive to unprotected seedlings. The experiments show that screening entirely protects seedlings from injuries by maggots, and indicate that it is possible to season the plants, by removal of the covering a few days before transplanting, so as to avoid the excessive wilting and losses which sometimes attend the planting in the field of sets grown in covered frames.

Dipping of nursery stock in the lime-sulphur wash.— Dipping in the lime-sulphur wash is a method of treatment proposed for the disinfecting of nursery stock for such pests as the San José scale, wooly aphis and other destructive insects. Its utility for these pur-

poses has not been thoroughly established, and more knowledge on the safeness and efficiency of this treatment has been desired. Bulletin No. 302 is a contribution of additional data, which are based on experiments to determine: (1) The effectiveness of the lime-sulphur wash as a dip on the San José scale, and (2) the effects of dipping in this mixture upon the health of nursery trees.

Tests were made with the standard lime-sulphur wash at temperatures of 60°, 100°, 120°, and 212° F. For purposes of comparison, experiments were also made with kerosene emulsion, containing 10, 15, and 20 per ct. of oil; miscible oil diluted with 10, 15 and 20 parts of water; and hydrocyanic acid gas at the rate of 0.3 gram of potassium cyanide per cubic foot. The stock used for these tests was 180 3-year old Bartlett pears and 970 3-year old Ben Davis apples, all of which were infested with the San José scale; and 300 Mann apples, 470 Bartlett pears, 300 Satsuma plums and 300 Fitzgerald peaches, all of which were clean and healthy trees.

While good results were secured from some of the spraying mixtures used in these tests, the practice of dipping cannot be recommended as a general substitute for fumigation with hydrocyanic gas. None of the mixtures were as effective on the San José scale as the gas, except under conditions destructive to the trees, while fumigation, if properly conducted, is harmless.

Control of leaf blister mite in apple orchards.— Bulletin No. 306 deals largely with experiments to determine the comparative merits of various sulphur sprays in preventing spotting of apple foliage by the leaf blister-mite. The mixtures that were tested were the boiled lime-sulphur wash, the home-made concentrated lime-sulphur wash, and two commercial preparations; and all of them gave equally satisfactory results. One application of either of these sprays has practically prevented spotting of foliage by the mite. With the increased availability of the sulphur sprays these are recommended as practicable remedies for the treatment of apple orchards. A plan of spraying that is well adapted for the treatment of apple trees is an application of a sulphur wash as the buds are swelling and before the leaves appear, followed by the usual second and third applications of the bordeaux mixture in their proper season.

DEPARTMENT OF HORTICULTURE.

Distribution of Station strawberries and raspberries.— In the Spring of 1908 the Station distributed four new varieties of red raspberries and three new varieties of strawberries. These varieties were the incidental outcome of the experimental work in plant breeding. Bulletin No. 298 gives full descriptions of the seven new varieties and briefly discusses the objects of the breeding work which brought them forth. The objects, briefly stated, are: (1) The study of the correlations of the different characters of plants; (2) investigations of the laws of inheritance and variability; (3) the adaptation of plants to new environment; (4) the development of hardy plants; (5) the development of resistance to disease; (6) improvement through crossing and hybridizing as a basis for generalizations as to the use of these operations in plant breeding; (7) systematic selection from pure-bred seedlings; (8) to discover what botanical and horticultural groups of the several fruits and vegetables best transmit their characters to their offspring either as pure-breds or in crosses; and (9) incidental to the above lines of research, the production of new varieties.

The relation of weather to the setting of fruit; with blooming data for 866 varieties of fruit.— In Bulletin No. 299 attention is called to the fact that the relations of weather to the formation and development of fruit have been lost sight of in the current discussions of the failures of blossoms to set fruits. Data are given to show that unfavorable weather is the predominating one of the several factors which cause the loss of fruit crops during blooming time. The following constituents of weather, with their relations to the setting of fruit, are discussed: Late frosts, wet weather, temperature, daily range in temperature, sunny weather, wind, and fogs. Means of controlling weather are discussed, the selection of locations with reference to general and local climate receive attention, and the fact that varieties of fruits may be selected with reference to their ability to withstand injurious weather is given a somewhat full discussion. The time of blooming is a particularly important period in the growing of fruits as to the welfare of crops regarding other factors than weather; as, to secure proper cross-fertilization, and in their relations to insects and fungi. The blooming data for the varieties of fruit grown on the Station grounds, 866 in all, are therefore given in this bulletin with a discussion of the uses to which such information may be put.

Varieties of strawberries, with cultural directions.— Bulletin No. 309 describes the newer varieties of strawberries with some of the standard kinds for comparison. These descriptions are followed by some cultural directions so that the bulletin may be used in answering the numerous inquiries which come to the Station in regard to the growing of strawberries. In describing the varieties an effort has been made to lay especial emphasis on the good and the poor characters of the new sorts as tested under the conditions at this Station. Attention is called to the fact that the results as published are not to be taken as absolute and that they may not even indicate what might be expected under widely different conditions of environment.

PUBLICATIONS ISSUED DURING 1908.

BULLETINS.

No. 296. January. Control of scale in old apple orchards. P. J. Parrott, H. E. Hodgkiss and W. J. Schoene. Pages 30, plates 4.
Popular edition, pages 8.

No. 297. February. Investigations on some fruit diseases. H. J. Eustace. Pages 18, plates 7.
Popular edition, pages 5.

No. 298. March. Distribution of Station strawberries and raspberries. U. P. Hedrick and O. M. Taylor. Pages 10, plates 4.
No popular edition.

No. 299. March. The relation of weather to the setting of fruit; with blooming data for 866 varieties of fruit. U. P. Hedrick. Pages 80.
Popular edition, pages 7.

No. 300. March. Inoculation as a factor in growing alfalfa. H. A. Harding and J. K. Wison. Pages 26, plates 2.
Popular edition, pages 10.

No. 301. March. Screening for the protection of cabbage seed beds. W. J. Schoene. Pages 10, plate 1.
Popular edition, pages 3.

No. 302. April. Dipping of nursery stock in the lime-sulphur wash. P. J. Parrott, H. E. Hodgkiss and W. J. Schoene. Pages 28, plates 2.
Popular edition, pages 3.

No. 303. July. Inspection of feeding stuffs. Pages 52.
No popular edition.

No. 304. November. Report of analysis of samples of fertilizers collected by the Commissioner of Agriculture during 1908. Pages 77.
No popular edition.

No. 305. December. Troubles of alfalfa in New York State. F. C. Stewart, G. T. French and J. K. Wilson. Pages 84, plates 12.
Popular edition, pages 13, figs. 2.

No. 306. December. Control of leaf blister mite in apple orchards. P. J. Parrott. Pages 22.
Popular edition, pages 5.

No. 307. December. Potato spraying experiments in 1907. F. C. Stewart, G. T. French and F. A. Sirrine. Pages 32.
Popular edition in conjunction with No. 311, January, 1909.

No. 308. December. Methods of paying for milk at cheese-factories. L. L. Van Slyke. Pages 38.
Popular edition (in preparation).

No. 309. December. Varieties of strawberries, with cultural directions. O. M. Taylor. Pages 51, plates 8.
Popular edition (in preparation).

No. 310. December. Director's report for 1908. W. H. Jordan. Pages 21.
No popular edition.

TECHNICAL BULLETINS.

No. 7. October. The Sporotrichum bud-rot of carnations and the silver top of June grass. F. C. Stewart and H. E. Hodgkiss. Pages 37, plates 6.

No. 8. December. The bacterial flora of cheddar cheese. H. A. Harding and M. J. Prucha. Pages 74, figs. 11.

CIRCULAR.

No. 9. New Series. January 15, 1908. Remedies for the San José scale and directions for their use. P. J. Parrott. Pages 12, figs. 2.

W. H. JORDAN,
Director.

New York Agricultural Experiment Station,
Geneva, N. Y., Dec. 31, 1908.

REPORT

OF THE

Department of Bacteriology.

H. A. Harding, *Dairy Bacteriologist.*

M. J. Prucha, *Assistant Bacteriologist.*

J. K. Wilson, *Assistant Bacteriologist.*

TABLE OF CONTENTS.

Inoculation as a factor in growing alfalfa.

The bacterial flora of cheddar cheese.

REPORT OF THE DEPARTMENT OF BACTERIOLOGY.

INOCULATION AS A FACTOR IN GROWING ALFALFA.*

H. A. HARDING AND J. K. WILSON.

SUMMARY.

1. This bulletin records the need of inoculation and means for supplying this need as determined in 67 fields distributed among 33 counties of this State.

2. The bacteria, *Ps. radicicola,* which enable alfalfa to obtain nitrogen from the air were present, at least in small numbers, in practically all of the 67 experimental fields.

3. They were present in sufficient numbers to produce an inoculation in any considerable number of the young alfalfa plants in only one-third of these fields.

4. An attempt to supply the germs by applying pure cultures of *Ps. radicicola* to the seed, drying and sowing, resulted in almost complete failure.

5. Applying soil from an old alfalfa field at the rate of 150 to 300 pounds per acre invariably produced an abundant inoculation on these experimental fields.

6. While but 15 of the 67 experimental plats produced a successful crop without inoculation, 48 adjacent plats where inoculating soil had been applied produced successful crops. Accordingly alfalfa growing, on 33 of the 67 fields which were tested, was changed from a failure to a success by the application of inoculating soil.

*A reprint of Bulletin No. 300.

INTRODUCTION.

Alfalfa has long been grown in the central part of this State, notably around Syracuse, but within the past ten years its culture has spread. Now, alfalfa is being successfully grown in every agricultural county of the State. The main reason why the growth of this valuable forage plant was so long restricted to a few localities is found in the particular requirements of this plant; and the recent wide spread of its culture is evidence that these requirements are being fulfilled. However, failures are still numerous and the factors which make for success are not always understood. Good, clean seed is a prime requisite, the soil and subsoil should be well drained, the soil should contain a fair amount of fertility and should be so fitted as to prepare a good seed bed and at the same time kill a maximum number of weeds.

When proper attention has been given to all of these things there still remain the important factors of inoculation with the bacteria which enable alfalfa to obtain nitrogen from the air, and of lime. This bulletin presents the results of a study of the influence of inoculation as shown in coöperative experiments conducted during the past three seasons on sixty-seven farms in this State. In these experiments the aim was to ascertain the facts as to the need of inoculation in growing alfalfa on these farms. As this need is imperative in many cases, attention has been given to different means of supplying inoculation.

While these experiments have the advantage that they embody practically all types of the agricultural conditions to be met with in the State they are open to the criticism that they were rarely conducted by experienced experimenters and our supervision was limited to directions through correspondence and an occasional visit. These visits gave an opportunity to verify practically all of the data furnished by the farmers except that concerning the comparative yields of the respective plats and in this particular the farmers were well qualified to determine and report the facts.

In work of this kind the need of a check plat to serve as a basis for computing the effect of any line of treatment is imperative. The most common error with these experimenters was either to omit the check plat or to so locate it that it was rendered worthless by surface drainage or agricultural operations. All experiments where the check plat was absent or where, for any reason, the results from it were of doubtful value, have been eliminated from our computations.

The peculiar feature of this work was the attempt to determine

quantitatively the probable importance of inoculation in growing alfalfa in this State. The contributions to the subject are: First, evidence that inoculation is at present one of the large factors in the successful growing of alfalfa in nearly all portions of the State; and, second, the fact that there is an important practical difference between the presence of a small number of the required germs in the soil and the presence of sufficient inoculation to supply the needs of the crop in this respect.

ACKNOWLEDGEMENTS.

The success of these experiments has depended largely upon the real coöperation of the farmers who have had them immediately in charge. To them we return our sincere thanks, trusting that the assistance which these results may be to their fellow farmers will be their most acceptable reward.

As this was, to an unusual extent, a series of experiments in which several of the Station staff have assisted, any further credit due should be ascribed to the Station as a whole, the authors assuming the responsibility for any mistakes which may have been made.

IMPORTANCE OF INOCULATION.

HISTORY.

A widespread interest in the subject of inoculation for legumes has been manifested at three distinct periods. The first was in 1886. At that time many investigators were searching for the source of the increase of our available nitrogen and the announcement of Hellriegel immediately turned scientific attention in this direction. Again in 1896 the "Nitragin" of Nobbe and Hiltner promised a ready means of making the earlier scientific discoveries of general application to agriculture and, while it failed of its original purpose, it started a line of work which has continued down to the present time.

The center of interest on these occasions was in Europe and there was little expression on the subject in this country outside of the circle of scientific workers. However, in 1904 when the U. S. Department of Agriculture announced a new method of transporting the legume cultures dried on cotton, not only the scientists but, to a remarkable extent, the farmers became keenly interested. This was at least partly accounted for by the extensive interest in the growing of alfalfa and the conviction that much of the difficulty which had been experienced in growing this crop was due to the lack of inoculation.

The practice of spreading good soil over land for the purpose of increasing its productivity is so old that its origin is lost in antiquity. It was doubtless observed that in some cases this application of soil had a very marked effect in stimulating the growth of legumes but the true reason for this stimulation was first demonstrated by Hellriegel and Wilfarth. They began these investigations in 1883, gave a partial report[1] of their results in 1886 and published them[2] in full in 1888. These investigations demonstrated that the ability of legumes to gather nitrogen from the air is dependent upon the presence of bacteria, now called *Ps. radicicola,* within their roots. It was found that a small amount of soil from a field in which peas had been successfully grown sufficed to inoculate peas growing in pots of sterilized sand while a portion of the same soil had no effect upon serradella grown under similar conditions. Soil from a second field where serradella was growing was efficient in inoculating the experimental serradella.

In these and similar experiments later conducted by other experimenters the soil was not applied directly to the experimental pots but a weighed portion of soil was shaken with a measured amount of water and after the solids had settled the water was applied to the pots. This method was resorted to in order to avoid adding to the experimental pots the various insoluble substances which were present in the inoculating soils. The results of Hellriegel and Wilfarth's investigations were tested in this way and found correct by Prazmowski,[3] by Lawes and Gilbert, [4] by Nobbe and Hiltner,[5] by Beyerinck,[6] and by Atwater and Woods.[7]

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[1] Hellriegel, H. Welche Stickstoffsquellen stehen der Pflanze zu Gebote. *Ztschr. Ver. Rübenzucker Industrie des Deut. Reichs,* 1886: pp. 863–877.

[2] Hellriegel, H., & Wilfarth, H. Untersuchungen über die Stickstoffnahrung der Gramineen und Leguminosen. *Ztschr. Ver. Rübenzucker Industrie,* 1888: Beilageheft, pp. 1–234.

[3] Prazmowski, Adam. Ueber die Wurzelknöllchen der Leguminosen. *Bot. Centbl.,* 36: 1888 and Die Wurzellnöllchen der Erbse. *Landw. Vers. Stat.,* 37: 161–238. 1890.

[4] Lawes, J. B., & Gilbert, H. New experiments on the fixation of nitrogen. *Proceed. Roy. Soc. Eng.,* 47: 1890.

[5] Nobbe, F., Schmid, E., Hiltner, L., & Hotter, E. Versuche über die Stickstoff-Assimilation der Leguminosen. *Landw. Vers. Stat.,* 39: 327–359. 1891.

[6] Beyerinck, M. W. Die Bacterien der Papilionaceen-Knöllchen. *Bot. Ztg.,* 46: 725. 1888.

[7] Atwater, W. O., & Woods, C. D. The acquisition of atmospheric nitrogen by plants. Storrs (Conn.) Agr. Exp. Sta. Rept. 2: 11–31. 1889.

Immediately after the announcement in 1886 that the bacteria were a necessary part of the fixation of nitrogen by legumes and that they could be supplied by additions of soil, Salfeld[8] began an extensive test of the application of inoculating soil to peat lands upon which legumes were to be grown. The results of this application were highly satisfactory and opened the way to profitable returns from lands of this class, which are abundant in many parts of Europe. Similar favorable results in Europe from the use of inoculating soil were reported by Fruwirth,[9] Wilfarth,[10] Schmitter,[11] and Miller.[12] When inoculation was lacking, the results were marked but where the desired bacteria were already present in the field in sufficient quantities the addition of soil from another field was, naturally, without any marked effect.

While the accuracy of the work of Hellriegel and Wilfarth was promptly tested by Atwater and Woods the practical application of these discoveries to American agriculture came about very slowly. We are indebted to Prof. I. P. Roberts and his colleagues[13] for an account of one of the earliest successes in this line. For a number of seasons the attempt had been made to grow soy beans at the Cornell University Agricultural Experiment Station, and it was observed that their roots were devoid of nodules. Prof. Roberts wrote to an acquaintance in Japan in regard to the matter and received about four ounces of soil. Some soy beans were planted in pots in the greenhouses in 1896 and the inoculating soil was mixed with the soil in the pots after they were filled. The nodules did not develop on the extreme ends of the roots of the beans but only on the upper two-thirds of the roots, from which it might be inferred that the soil was not thoroughly mixed. In the check no nodules were formed while in the others the nodules were not only abundant but were unusually large. The next season the soil from

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[8] Salfeld, A. Ueber die Verwertung der Hellriegel' schen Versuche mit Leguminosen in landwirtschaftlichen Betrieb. *Biedermann's Centbl. Agr. Chem.*, 18: 239-244. 1889.

[9] Fruwirth. Neue Impfverseuche mit Lupinen. *Deut. landw. Presse.*, 1892 & 1893.

[10] Wilfarth, H. Die neueren Verseuche mit Stickstoffsammelenden Pflanzen und deren Verwertung für den landwirtschaftlichen Betrieb. *Biedermann's Centbl. Agr. Chem.*, 22: 181-184. 1893.

[11] Schmitter, A. Die Impfung der Lehmsboden zu Lupinen mit Bakterienreicher Erde. *Biedermann's Centbl. Agr. Chem.*, 23: 700-701. 1894.

[12] Miller. *Jour. Roy. Agr. Soc. Eng.*, Series III., 7: 236-253. 1896.

[13] Through personal letters from Prof. Roberts and Prof. Stone.

the two inoculated pots was used in the field by placing a small portion of it in the hill with each bean seed. Several square rods were inoculated in this way. These soy beans produced nodules abundantly and from that time soy beans grown in that immediate vicinity have produced nodules.

In Alabama Duggar[14] used soil successfully to inoculate alfalfa in 1897 and similar inoculation results with soy beans were obtained in Kansas by Otis[15] in 1898. Hopkins[16] at Illinois had marked results from pot experiments in 1901 in which he inoculated alfalfa with liquid from Kansas soil. An acre inoculated at the same time with a portion of the same soil showed marked results in favor of the inoculation in the spring of 1902. Later he inoculated 25 alfalfa fields about the State and, wherever inoculation was lacking, as seemed to be the case in most fields, he obtained good results from the inoculating soil. His contribution to the subject was the observation that equally good results in the inoculation of alfalfa were apparently obtained when the soil used contained nodules of sweet clover (*Melilotus alba*) as when it came from an old alfalfa field. Russell and Moore[17] and Nash[18] likewise obtained equally good results from the use of soil containing sweet clover and that containing alfalfa nodules.

The extent to which inoculation has become a part of the farm practice in this country can be judged from the fact that over 1,200 farmers have obtained soil for inoculating alfalfa from a single commercial source in this State within the past five years.

From the very first it was appreciated that the use of soil for carrying the desired bacteria from one field to another was a crude and inconvenient method; and investigators set about isolating *Ps. radicicola* and propagating it in pure cultures. The earliest attempt to use these cultures in the inoculation of considerable areas seems to have been made by Nobbe and Hiltner and their success was such that they put the cultures upon the market under the

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[14] Duggar, J. F. Soil inoculation for leguminous plants. Ala. Agr. Exp. Sta. Bul. 87. 1897.

[15] Otis, D. H. Soil inoculation for soy beans. Kan. Agr. Exp. Sta. Bul. 96, 1900.

[16] Hopkins, C. G. Alfalfa on Illinois soil. Ill. Agr. Exp. Sta. Bul. 76 (1902) and Nitrogen bacteria and legumes. Bul. 94. 1904.

[17] Russell, H. L., & Moore, R. A. Inoculation experiments with alfalfa and soy beans. Wis. Agr. Exp. Sta. Rept. 22: 242–261. 1905.

[18] Nash, C. W. Alfalfa in Maryland. Md. Agr. Exp. Sta. Bul. 118. 1907.

name of "Nitragin." Partly on account of the naturally small demand for this new article and partly on account of the poor results obtained by various investigators who tested these cultures they ceased to be offered for sale. Hiltner has steadily continued his studies of this subject and has found a solution for many of the difficulties which earlier beset the preparation of cultures of sufficient vigor to accomplish the desired fixation of nitrogen.

The problem of the production of cultures of *Ps. radicicola* which would be a satisfactory substitute for soil in the inoculation of legumes was undertaken by the U. S. Department of Agriculture and in 1904 one of its investigators patented[19] a process which was expected to furnish the bacteria in a vigorous condition and in a form which would allow their ready distribution. It was soon found that this method was a failure[20] and attention has more recently been given to other methods of preparation and distribution. A report[21] of progress has just been made which indicates that the results obtained by the new Department methods are still less than one-half as good as those obtained from the use of inoculating soil. Pure cultures have been sent out in various forms and on a considerable scale from both the Virginia[22] and the Ontario[23] agricultural experiment stations.

While it has been found that there is rarely any need for artificial inoculation in growing a legume which is a common crop in any district, there is often the need of inoculation in order to grow successfully a legume which has never been grown in that locality.

PLAN OF EXPERIMENTS.

During the past three seasons the proposition has been made to all farmers who inquired regarding inoculation for alfalfa that the Station would furnish the inoculating material if the farmer would follow general drections and report the progress of the experiment.

[19] Letters Patent No. 755,519. Dated March 22, 1904. Issued to George T. Moore.

[20] Harding, H. A., & Prucha, M. J. The quality of commercial cultures for legumes. N. Y. Agr. Exp. Sta. Bul. 270, 1905. Same in Annual Rept.

[21] Kellerman, Karl F., & Robinson, T. R. Progress in legume inoculation. U. S. Dept. of Agr., Farmers' Bul. 315. 1908.

[22] Ferguson, Meade. Soil inoculation with artificial cultures. Va. Agr. Exp. Sta. Bul. 159. 1906.

[23] Harrison, F. C., & Barlow, B. Co-operative experiments with nodule-forming bacteria. Ontario (Canada) Agr. Exp. Sta. Bul. 148. 1906.

In 1905 the selection of the land and the laying out of the plats were left to the farmers except that an uninoculated portion or check was required. In 1906 general directions for selecting and fitting the land designed for the experiment were furnished and it was suggested that the experimental acre be laid out according to the adjoining diagram. In 1907 a compliance with the latter suggestion was insisted upon except where, for local reasons, a different arrangement was evidently preferable.

No lime, no inoculation.	Lime, no inoculation.
No lime, inoculation.	Lime and inoculation.

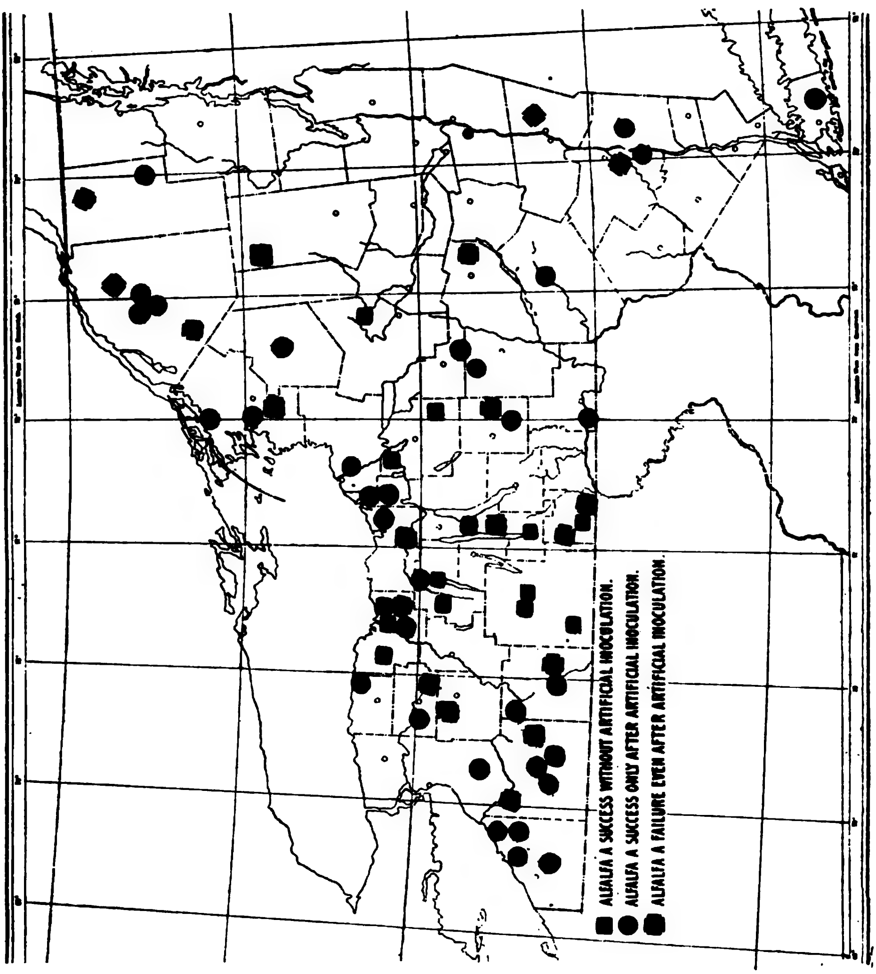
Down-hill side of field.

The uninoculated area was intended to furnish evidence as to the amount and distribution of any inoculation originally present in the field as well as serving as a basis for judging the effect of the artificial inoculation or the lime applied to the adjoining areas.

The experimenters were supplied with blanks for recording the nature and condition of the soil at seeding time as well as the condition of each plat at intervals during the first two seasons. In most cases the reports were supplemented by personal visits each season, when the records were verified and enlarged as much as possible.

In attempting to draw conclusions from experiments conducted in this manner we have been sensible of the difficulties connected with obtaining accurate data and we have excluded incomplete experiments so rigidly that our actual calculations are based upon only 67 of the 118 experiments which were actually begun. These 67 experiments have, for the most part, been personally examined and are known to have been so conducted as to give dependable results. Among them are a few which were not seen but which were so well arranged and the reports from which are so clear as to leave little room for doubt as to the actual conditions.

It will be noted from the plan of the experiments begun in 1906 that lime was to be applied to one-half of the experimental area. The results already obtained show that lime is often an important factor in the growing of alfalfa. A detailed discussion of our results with lime will be given in connection with our report, next year, upon the experiments which were begun in 1907.



MAP I.— LOCATION OF ALFALFA–INOCULATION EXPERIMENTS.

GEOGRAPHICAL DISTRIBUTION OF THE EXPERIMENTS.

The accompanying map shows the location of the experiments from which the data in this bulletin were taken. They are distributed among 33 of the 61 counties of this State. In addition to the experiments shown on the map, 51 other experiments were started at various places.

It should be clearly understood that none of the 51 experiments which are not considered in our computations was omitted because it failed to produce a good yield of hay. Many of them did give excellent returns in hay but, owing to mistakes in laying them out, accidents in connection with sowing or the growth of the plants or failure to report clearly the progress of the experiment, we were unable to determine which were the factors producing the results.

An exmination of the accompanying map shows that the successful growing of alfalfa is not restricted to any given area. Even the fields where it thrived without artificial inoculation are widely scattered. Not only is it a success in all portions of the State but there are successful fields on soil ranging from loose sand to clay loam underlaid by a resistant hardpan.

The successful growing of alfalfa is not a matter of regional or climatic differences but depends upon the past treatment and present condition of the particular field in which it is sown.

PREVALENCE OF NATURAL INOCULATION.

Since the bacteria working in connection with the plant enable it to get an increased amount of nitrogen, the presence of inoculation on our check plats could usually be detected by the vigorous appearance of the plants. After the first season, the uninoculated plants, if alive, are usually smaller and somewhat yellow. Often, toward the close of the first season in a field but slightly inoculated, the inoculated plants can easily be found by their greener color and general evidence of vigor. The difference in the rate of growth is brought out in the photograph (Plate I). This shows the growth on one of our experimental fields which had been inoculated with soil and similar growth on an adjoining check plat which had the same treatment except that it had not received artificial inoculation.

Appearance of alfalfa nodules.— A more accurate idea concerning the presence of inoculation in the fields than can be obtained from the general observation of the plants may be had by examining the roots of the plants for the presence of nodules, and noting their number and size.

Alfalfa nodules occur singly and in clusters of various kinds. They are usually found upon the fine roots or attached to the larger roots by a short branch. The single nodules are usually about the size and shape of an alfalfa seed but in exceptional cases they may be larger than a kernel of wheat. Often two or more nodules are attached at a common point and radiate like a fan. At times an irregularly shaped mass is formed from which the nodules radiate, resembling the palm and fingers of the hand. In some fields there is an abundant formation of giant clusters, often a half-inch across, in which large numbers of the individual nodules are set together in a mass radiating from a common center, at which they are attached to a fine root.

The prevailing color of the young growing nodule is white, often with a tinge of green at one end. The older nodules are darker in color, possibly through staining by the soil solution. Late in the season many of the nodules appear brown and shriveled as though their contents had been withdrawn.

How to find the nodules.— When conditions are favorable nodules are formed very promptly. In some germination experiments by F. C. Stewart, Botanist of this Station, nodules were well developed by the time the first true leaves were formed and the seedlings were less than an inch high. A photograph of slightly older seedlings is shown in Plate II.

The nodules are most easily found during the first two seasons since the root systems are then comparatively near the surface. With each succeeding season the fine roots are at greater depths and the difficulty in finding nodules is proportionately increased. The nature and condition of the soil are also considerable factors in the chance of success. In clay ground, particularly when it is dry, it is difficult to remove the dirt from the roots without removing the nodules at the same time. In light, sandy soils, especially when these are moist, there is little chance of overlooking the nodules if moderate care is exercised and the person knows a nodule when he sees it.

It is best to dig up a block of earth containing the plant to be examined and if the soil is in the proper condition the dirt may be carefully removed from the roots with the hands. If the soil is hard and dry it is best to use water in separating the dirt from the roots. Where plants are pulled up bodily as is sometimes done the nodules uniformly remain in the ground. The number of nodules will often vary greatly on adjoining plants and a consider-

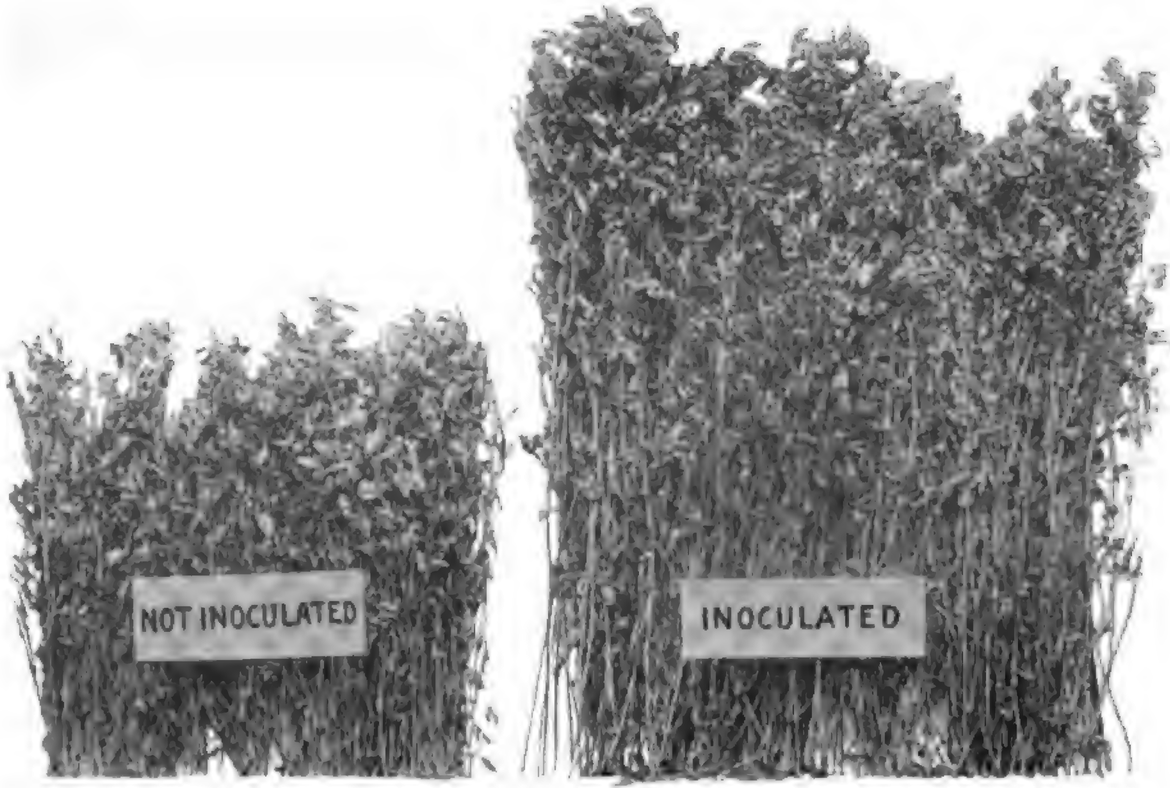


Plate I.—Alfalfa: Height on Adjoining Plats. Difference Due to Application of Inoculating Soil.

able number of plants should be examined before concluding as to the amount of inoculation present in a field.

Presence of nodules in the uninoculated fields.— Examination of the 67 check plats showed the presence of nodules on at least a few of the plants in all but 5 plats. Two of these plats were among those not seen by a Station representative, the reports having been made by the co-operating farmers. The fact that nodules were found by the same farmers on their adjoining inoculated plats shows that they understood what they were looking for and they would probably have found the nodules had they been present in any considerable numbers. However, the repeated failure of other farmers to find the nodules where we later found them present in small numbers would suggest that there may have been a few inoculated plants that were overlooked in these check plats. In one case where we examined a check plat without finding any inoculated plants the check plat was such a failure that all of the plants were dead and the land ploughed; so there was nothing left to examine. The dryness and hardness of the soil were probably responsible for the failure to find any nodules in the other two fields. On each of these five check plats the alfalfa crop was a failure.

While it should not be forgotten that the adjacent inoculated plats contributed in some cases to the inoculation of the check plats, the fact that some inoculation was practically everywhere present and the way that the inoculated plants were distributed over the plats make it probable that at least a small amount of natural inoculation is present in all cases.

Source of this widespread inoculation.— One explanation for the wide distribution of these germs which has been here observed is that the bacteria are carried upon the seed. When the slight contact which the seed has had with the soil is remembered in connection with the rapidity with which the legume bacteria are killed by drying it would seem that this method of transportation is highly improbable. However, Ferguson[24] states that legume bacteria are carried upon seed and in a personal letter explains that he has recovered them from commercial alfalfa seed by laboratory methods. This would seem to settle the fact that they are sometimes carried in this way; but the results which will be given under the heading, "Inoculation by living cultures placed upon the seed," tend to show that seed is poorly adapted for transporting these

[24] See footnote 22.

bacteria and that only a very small proportion of those getting upon the seed would survive until the time of sowing.

A more probable source of this natural infection is the germs from the other species of legumes. Reference has already been made to investigations which indicate that the bacteria associated with sweet clover and with burr clover readily associate with alfalfa. The number of species of wild legumes which grow naturally and with an abundant formation of nodules in our fields is large and it would be strange if the two forms already known were the only ones from which the germs pass readily to the alfalfa. It has been found in a number of investigations that when legumes are grown in sterilized soil and are heavily inoculated with cultures derived from other species of legumes nodules are produced in many instances.

NEED OF ARTIFICIAL INOCULATION.

When we consider that only 15 of the 67 check plats produced sufficient hay to be considered a profitable crop although they were practically all at least slightly inoculated it is readily seen that something more than the presence of a scattering inoculation is necessary in order to make alfalfa growing profitable. That many plats were a failure simply because of a lack of sufficient inoculation will be seen from the results obtained upon adjoining plats where artificial inoculation was supplied.

The question which is important agriculturally is whether there is sufficient inoculation in order to insure a successful crop, so far as it is affected by that factor. The experimental fields presented all gradations between no inoculation and a very abundant one. In some fields it was easy to see that there was not enough inoculation and in others that there was sufficient, but in many cases one could not decide from an observation of the roots as to the real situation. There seemed to be no better way than to wait until the second season, when the plants should be fully established, and let the verdict turn on whether the crop produced was sufficient to be considered a profitable one. On this account we are reporting at this time only upon the experiments begun in 1905 and 1906. The results of the experiments begun in 1907 will probably be given in a bulletin of 1909.

While 67 fields are too few in comparison with the number of fields in the State to form a satisfactory basis for generalization, so far as they go the results from them indicate that less than one-quarter of the fields are in condition to produce alfalfa suc-

Plate II.— Location and Appearance of Nodules on Alfalfa Seedlings.

cessfully without artificial inoculation. The extent to which they will grow this crop successfully when this inoculation is supplied will be brought out under a later heading.

METHODS FOR SUPPLYING INOCULATION.

The methods which have been advacated for supplying the desired inoculation may be grouped under the following heads: (1) Reseeding with alfalfa the field which has failed; (2) applying the commercial cultures dried upon cotton; (3) applying living cultures of *Ps. radicicola* to the seed; (4) applying soil from an old alfalfa field.

Reseeding with alfalfa.— It is a common observation that a second trial of alfalfa often succeeds upon a field where the first attempt was a failure. When the failure is due to a lack of inoculation, the scattering nodules produced act as centers for multiplying the desired germs. When the field is ploughed these germs are scattered broadcast and are ready to enter the roots of the succeeding crop.

Under certain conditions this may be a desirable way of building up an inoculation in a small area from which the soil may later be used for inoculating large areas. It has the advantage that it reduces to the minimum the danger of introducing objectionable weeds and pests. Its disadvantages lies in the fact that by such a method it may take two or three years before a successful stand can be obtained and meanwhile the expense in labor, seed and use of ground is considerable.

Using commercial cultures.— The directions accompanying the commercial cultures which were upon the market in 1905 and 1906, stated that after being moistened by the solution containing the bacteria the seed should be air-dried in the shade. If the seed was kept dry the inoculation would remain active for several weeks. As has been shown in detail in Bulletins 270 and 282 of this Station the commercial cultures upon the market have been of no practical value because they did not carry an appreciable number of living germs. Accordingly we did not attempt to test their efficiency by field experiments. The wisdom of our action in this respect is shown by the fact that all of the agricultural experiment station workers[25] who have tested these cultures unite in saying that no results can be expected from this form of culture.

[25] For a list of such Stations see footnote in N. Y. Agr. Exp. Sta. Bul. 282. 1906.

Inoculation by living cultures placed upon the seed.—When it was found that the commercial cultures did not contain an appreciable number of living *Ps. radicicola* it was decided to test the efficiency of the final steps in the proposed process of inoculation by treating alfalfa seed with living cultures of this germ. Accordingly the seed was treated with the culture, air-dried according to the directions furnished with the commercial culture and sown in plats beside similar plats of untreated seed.

In order that there should be no question but that the seed was treated with an abundance of the desired germs it was all inoculated at the Station laboratory by M. J. Prucha, Assistant Bacteriologist, with a pure culture of *Ps. radicicola* developed in a nitrogen-free medium according to the most approved methods. The culture which was used in most cases had been kindly furnished us by the U. S. Department of Agriculture as explained in Bulletin 270, page 361. In other cases we used a pure culture which had been isolated from an alfalfa nodule in our laboratory.

Twenty-four farmers conducted tests of the efficiency of this method of inoculation in 1905. In order that seed from the same lot should be used on the inoculated and the uninoculated plats of each experiment each of the twenty-four farmers sent a portion of his seed to the Station for inoculation. There it was inoculated separately and returned by express as soon as thoroughly air-dried. The alfalfa seed inoculated in this way amounted to seventeen and one-half bushels.

In most cases the test of inoculation upon the seed was conducted by the same farmers who were testing the effect of inoculation by means of soil and in such cases the check and two test plats were exposed to practically identical conditions except in the matter of inoculation.

Of the 24 experiments with inoculated seed but 18 were so conducted and reported that the results can be relied upon. Twelve of these experiments were visited by a Station representative.

The results of these eighteen tests of the effect of inoculation by means of pure cultures of *Ps. radicicola* placed upon the alfalfa seed are given in Table I.

TABLE I.—EXPERIMENTS SHOWING THE RESULTS ON THE CROP WHERE *Ps. radicicola* WAS APPLIED TO THE ALFALFA SEED.

NAME.	Post-office.	County.	Township.	CHECK.		INOCULATED SEED.	
				Nodules.	Success.	Nodules.	Success.
Austin, James*	Morton	Monroe	Hamlin	+	—	+	—
Brady, C. J.	Canandaigua	Ontario	Canandaigua	+	+	+	+
Brokaw, M. C.	Interlaken	Seneca	Lodi	+	+	+	+
Cady, S. A.	Troupsburg	Steuben	Troupsburg	+	+	+	+
Cook, H. E.	Denmark	Lewis	Denmark	+	+	+	+
Hendricks, C. S.*	Wolcott	Wayne	Huron	+	—	+	—
Hinkley, B.	Spencerport	Monroe	Ogden	+	+	+	+
House, J. A.	Glenfield	Lewis	Greig	+	—	+	—
Husted, R. A.	Stanfordville	Dutchess	Stanford	+	—	+	+
Ioset, J. A.	Baldwinsville	Onondaga	Lysander	+	+	+	+
James, D. L.	Rushford	Allegany	Rushford	+	—	+	—
Kingsbury, C. H.	Barnard	Monroe	Greece	+	+	+	+
Nevins Brothers*	Forestville	Chautauqua	Hanover	—	—	+	+
Robbins, E. T.*	Brighton	Monroe	Brighton	+	—	+	—
Ruestow, E. H.	Barnard	Monroe	Greece	+	+	+	+
Van Alstyne, H.	Old Chatham	Columbia	Chatham	+	—	+	—
Wells, J. O.*	Shortsville	Wayne	Galen	+	—	+	—
Whitford, E. A.*	Adams Center	Jefferson	Adams	+	—	+	—
Totals				+17 — 1	+ 8 —10	+18 — 0	+10 — 8

* Field not seen by a station representative.

The results from the seed-inoculated plats are identical with those from the corresponding check plats except in two intsances, those of Nevins Bros. and R. A. Husted. The experiment of Nevins Bros. was not seen by a Station representative, but from the reports furnished it would seem that the seed-inoculated plats were better than the check plats and were good enough to be considered a success. The experiment with Mr. Husted was personally inspected and the seed-inoculated plat was distinctly better than the check plat.

Aside from these two experiments there is no evidence from our experiments that carefully inoculated seed carried enough living *Ps. radicicola* to be of any use upon the fields; and an examination of the plats showed few if any indications of an improvement resulting from a treatment of the seed with pure cultures of *Ps. radicicola.* The unfavorable result from this method of inoculation was as unexpected as it was unfortunate. The explanation of this rapid disappearance of the germs placed upon the seed has been given by Kellerman and Beckwith,[26] who pointed out that the high osmotic pressures developed in evaporating the solution in which the bacteria were grown is quickly fatal to the germs themselves.

As will be seen from the results from inoculation by means of soil, 15 of these farmers had plats inoculated in this manner adjoining the seed-inoculated plats and in all cases except that of Mr. Robbins the soil-inoculated plats were a success. Not only was a failure transformed into a success by the inoculating soil in a number of cases but even on succcessful fields where the amount of inoculation naturally present was not up to the full requirement of the alfalfa, the growth of this plant was noticeably stimulated by the application of soil. On the contrary the benefit derived from the treatment of the seed with pure cultures of *Ps. radicicola* was so slight in comparison with the good results obtained from the use of soil that the inoculation of the seed was not continued after the season of 1905.

[26] Kellerman, Karl F., & Beckwith, T. D. Effect of drying upon legume bacteria. *Science,* N. S., 23: 471–472. 1906.

Applying soil from an old alfalfa field.—While very satisfactory results from this form of inoculation have been reported by experiment stations and by individuals, the tests by stations have not been planned with the idea of determining the percentage of success due to its use, and the private tests have generally been

conducted without suitable check plats by which to measure the effect. Accordingly we have tested this method of inoculation in a considerable number of cases, with an equal number of check plats for comparison. The results thus obtained are useful both as an indication of what can be expected from the use of soil and also as a basis for measuring the relative value of the various other methods which have been suggested for producing the inoculation.

During 1905 we shipped soil to 54 farmers for the purpose of making these tests. The soil was obtained from one of our fields which had been in alfalfa for a long period and had produced heavy crops. Nodules were not easily found upon the alfalfa roots since the plants were old and were feeding at a considerable depth. The use of the soil from this field the preceding season at the rate of 100 lbs. per acre had produced good inoculation.

Owing to the late cutting of the alfalfa in the fall of 1904 there was little aftergrowth and the unusually severe winter of 1904–5 destroyed practically all of the plants. The results from the use of the soil show that the bacteria associated with the alfalfa were not destroyed.

The soil was prepared by removing a little of the surface and passing the remaining soil, down to a depth of about a foot, through a coarse sieve, in order to remove the small stones and put the soil in condition to pass through the fertilizer attachment of a seeder. The sifted soil was shipped to the farmers in bags or barrels. Each was directed to apply it to a portion of the field just previous to sowing the seed, leaving another portion of the field untreated as a check.

The results obtained from thirty-two of these experiments where the experiment was properly conducted and reported are given in Table II.

TABLE II.— EXPERIMENTS, BEGUN IN 1905, SHOWING EFFECT OF INOCULATING SOIL ON ALFALFA CROP.

NAME.	Post-office.	County.	Township.	CHECK.		INOCULATED.	
				Nodules.	Success.	Nodules.	Success.
Adams, H. B.	Wellsville	Allegany	Wellsville	+	—	+	—
Akins, G. B.*	Ovid	Seneca	Ovid	+	—	+	—
Allen, G. W.	Gowanda	Cattaraugus	Persia	+	—	+	—
Austin, James*	Morton	Monroe	Hamlin	+	—	+	+
Brady, C. J.	Canandaigua	Ontario	Canandiagua	+	+	+	+
Brokaw, M. C.	Interlaken	Seneca	Lodi	+	+	+	+
Cady, S. A.	Troupsburg	Steuben	Troupsburg	+	+	+	+
Church, W. H.	Wellsville	Allegany	Wellsville	+	—	+	+
Clothier, H. B.	Silver Creek	Chautauqua	Hanover	+	—	+	+
Garner, T. B.*	Cincinnatus	Cortland	Cincinnatus	—	—	+	—
Hendricks, C. S.*	Wolcott	Wayne	Huron	+	—	+	+
Hinkley, B.	Spencerport	Monroe	Ogden	+	+	+	+
House, J. H.	Glenfield	Lewis	Greig	+	—	+	+
Husted, R. A.	Stanfordville	Dutchess	Stanford	+	—	+	+
Ioset, J. A.	Baldwinsville	Onondaga	Lysander	+	+	+	+
Kingsbury, C. H.	Barnard	Monroe	Greece	+	+	+	+
James, D. L.	Rushford	Allegany	Rushford	+	—	+	+
Moe, O. J.	Burke	Franklin	Burke	—	—	+	—
Mosher, W. J.	Martville	Cayuga	Sterling	+	—	+	+
Nevins Brothers*	Forestville	Chautauqua	Hanover	—	—	+	+
Niebel, G. J.	Dunkirk	Chautauqua	....	—	—	+	+
Norman, A. J.	Charlotte	Chautauqua	....	+	—	+	+
Roberts, Miss	Highland	Ulster	Lloyd	+	—	+	—
Ross, F. D.	Corfu	Genesee	Pembroke	+	—	+	+
Robbins, E. F.*	Brighton	Monroe	Brighton	+	—	+	—
Toby, E. P.	Smyrna	Chenango	Smyrna	+	—	+	+
Usher, R. M.	Waterville	Oneida	Sangerfield	+	+	+	+
Van Alstyne, H.	Old Chatham	Columbia	Chatham	+	—	+	—
Warner, F. P.	Canandaigua	Ontario	Canandiagua	+	—	+	+
Whitford, E. A.*	Adams Center	Jefferson	Adams	+	—	+	—
Wheeler, O. F.	East Bloomfield	Ontario	Bloomfield	+	+	+	+
Wilcox, Chet.	Wellsburg	Chemung	Ashland	+	—	+	—
Totals	....	....	....	+28 — 4	+ 8 —24	+32 — 0	+22 —10

* Fields not seen by a station representative.

From the above table it will be seen that among the thirty-two experiments only eight of the check plats produced enough hay to make them a success while twenty-two of the adjoining plats which had been inoculated with soil from our alfalfa field produced enough hay to entitle them to be so classed. Since the two kinds of plats were in all cases in adjoining pairs and these pairs were treated alike except that inoculated soil was scattered over one of each pair of plats this difference in production can be correctly ascribed to the influence of the inoculating soil.

It should be remembered that the land for these experiments was selected by the farmers with little or no guidance in the matter and was fitted and sown with only very general directions. Some of the fields were not adapted to alfalfa on account of the poor drainage, while others were put in so hastily that the weeds overran and choked out the alfalfa. This result was often produced by a liberal application of stable manure which, while it added fertility, also added weed seed in abundance.

Profiting by the mistakes which were made in 1905 the experimenters in 1906 were urged to select their land for alfalfa with care as to its drainage and to fit it with a view to reducing its content of weed seed as much as possible. Of the 67 farmers who were furnished with soil 32 conducted their experiments in such a manner as to give dependable results which are summarized in Table III.

TABLE III.— EXPERIMENTS, BEGUN IN 1906, SHOWING EFFECT OF INOCULATING SOIL ON ALFALFA CROP.

NAME.	Post-office.	County.	Township.	CHECK.		INOCULATED.	
				Nodules.	Success.	Nodules.	Success.
Bennett, B *	Hornell	Steuben	Howard	+	+	+	+
Bennett, F.*	Hornell	Steuben	Howard	+	+	+	+
Brown, W. H	Vestal Center	Broome	Vestal	+	—	+	+
Bullis, James	Canton	St. Lawrence	Canton	+	—	+	+
Burnes, G. C	Burdett	Schuyler	Hector	+	+	+	+
Carman, A. A	Barneveld	Oneida	Trenton	+	+	+	+
Colyer, R. C	Woodbury	Nassau	Oyster Bay	+	—	+	+
Dow, Chas. M	Jamestown	Chautauqua	Randolph	+	—	+	+
Goodall, H. L	Lake Kushaqua	Franklin	Franklin	+	—	+	+
Grant, N. A	Potsdam	St. Lawrence	Potsdam	+	—	+	—
Hammond, D	Denver	Delaware	Roxbury	+	—	+	—
Hiller, H. R	Alexander	Genesee	Alexander	+	—	+	—
Hinds, O. E	Watertown	Jefferson	Pamelia	+	—	+	+
Irwin, W. A	Lafargeville	Jefferson	Orleans	+	—	+	+
Kingsbury, C. H	Barnard	Monroe	Greece	+	—	+	+
Leach, J. A	Marathon	Cortland	Marathon	+	—	+	+
Morehouse, A. J	Fulton	Oswego	Palermo	+	—	+	+
Mosher, W. J	Martville	Cayuga	Sterling	+	—	+	+
Napier, J. A	Franklinville	Cattaraugus	Machias	+	—	+	—
Northrup, Jay	Springville	Erie	Concord	+	—	+	+
Orr, W. J	Attica	Wyoming	Bennington	+	—	+	—
Pitt, M. E	Canton	St. Lawrence	Canton	+	—	+	+
Reeves, D. F	Steamburg	Cattaraugus	Cold Spring	+	—	+	+
Roberts, Miss	Highland	Ulster	Lloyd	+	—	+	+
Scott, J. F	Elmira	Chemung	Elmira	+	+	+	+
Smith, C. E	Gouverneur	St. Lawrence	Gouverneur	—	—	+	—
Smith, J. D	Delhi	Delaware	Meredith	+	—	+	+
Taylor, O. L	Canton	St. Lawrence	Canton	+	—	+	+
Wells, E. B	Clyde	Wayne	Galen	+	—	+	—
White, George	Elmira	Chemung	Elmira	+	—	+	—
Williams, K. R	Earlville	Madison	Lebanon	+	—	+	+
Winship, Charles	Little Valley	Cattaraugus	Little Valley	+	—	+	+
Totals				+32 — 1	+ 5 —28	+32 — 0	+24 — 9

* Fields not seen by a station representative.

It is seen from this table that while but 5 of the check plats could be considered a success, 24 of the adjoining plats to which soil had been added produced enough hay to make them profitable.

Combining the observations for these two years it is seen that natural inoculation was noted on all but 5 of the 65 check plats[27] while the growth of alfalfa was sufficient to be counted as a success on only 13 of these plats.

The application of inoculating soil to adjoining plats resulted in an abundant inoculation in all cases and 46 of these soil-inoculated plats produced successful crops of hay.

Comparing the results from the inoculated and the check plats it is seen that there was an increase in successful fields among the latter of 33 out of a total of 65. As the check and the inoculated plats were adjoining and had been treated alike, except in the matter of inoculation, this improvement may be justly ascribed to the application of the inoculating soil.

CONCLUSIONS.

A clear distinction should be made between the presence of nodules on a few plants in a field and the presence of sufficient inoculation to insure a successful crop so far as it is affected by this factor. Some nodules were found on practically all of our check plats while but 15 of these plats produced successful crops. The results from the adjoining inoculated plats show that 33 of these 65 check plats failed because they did not contain a sufficient amount of inoculation. From these results it will be easy to understand why, before attention was given to inoculation, alfalfa growing outside of certain regions was generally considered a hopeless undertaking.

The importance of inoculation is shown by the fact that where inoculating soil was applied 33 of the experimental fields were changed from a failure to a success. Instead of 13 successes as shown by the check plats there were 46 among the soil-inoculated plats.

Reduced to farm practice this would indicate that without the application of artificial inoculation alfalfa growing on carefully selected land is a very uncertain proposition with the chances 4 to 1 against success. Where inoculating soil has been applied to ground which has been carefully selected alfalfa growing becomes as certain of success as almost any of our common crops.

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[27] There were two additional check plats among the experiments with germs placed upon the seed.

THE BACTERIAL FLORA OF CHEDDAR CHEESE.*

H. A. HARDING AND M. J. PRUCHA.

SUMMARY.

1.— Recent developments in bacteriological technique have permitted a more intensive study of the flora of cheddar cheese than was previously possible. However, it is not yet certain that all the forms active in the cheese will grow upon our present culture media.

2.— A quantitative and qualitative study of the bacterial flora has been made during the ripening period in nine normal cheddar cheeses. Seven of these were manufactured under commercial conditions and represented four first-class factories.

3.— The quantitative changes go through a similar cycle in all cases but different cheeses vary widely both in the total number of germs present and in the age at which the maximum content is attained. There is no evident connection between the number of bacteria present and the rate at which the cheese ripens. When commercially ripe, a cheddar cheese usually contains some millions of living bacteria per gram.

4.— More than 300 pure cultures were isolated and finally reduced to 33 groups according to the classification of the Society of American Bacteriologists. Ten of these groups disappeared from the cheese at once; representatives of 9 other groups were found in but single cheeses, although each group persisted for some time in the cheese where found; the remaining 14 groups are the most important members of the cheese flora. The *Bacterium lactis acidi* of Leichman, which includes 4 of these 14 groups, is the only species which was always found and it practically always included over 99 per ct. of the total germ content.

INTRODUCTION.

The work here reported is a part of the investigation of cheese ripening which is being conducted jointly by the Dairy, the Chemical and the Bacteriological Departments of this Station. The re-

* A reprint of Technical Bulletin No. 8.

sults of these investigations have appeared in a series of bulletins[1] of which this is a continuation. Before discussing the part taken by bacteria in the ripening process it seemed necessary to determine as accurately as possible what kinds of bacteria are present in the cheese. This bulletin gives the results obtained from an intensive study of this phase of the problem during the past four years.

The changes which take place in ripening cheese have been the object of many investigations. These changes are known to result from the combined action of a number of factors, of which bacteria and enzyms are considered the most important.

All attempts at determining the part taken by bacteria in the changes in cheese have been handicapped by a lack of accurate information concerning the bacteria which are active during the ripening period. This lack of knowledge has not resulted from a failure to appreciate the value of such information but rather from the difficulty of acquiring it.

In the case of the cheese flora this difficulty is a very real one. The organisms which grow best in milk and its products do not flourish upon our artificial media and some forms do not grow there at all under ordinary conditions. Even when pure cultures have been obtained they are frequently lost before many observations have been made upon them.

In morphology, many of these cultures are so near the border line that a separation into the conventional coccus or bacillus is difficult; while their physiology is so variable that one wavers between the extremes either of putting them all into a single species or of making as many species as there are cultures. The universal acceptance of species as the unit of biological classification at present requires its use here although the concept upon which it was founded can not be applied to bacteria.

Species, as it was originally conceived and as it is at present used in the case of the higher plants and animals, is based primarily upon morphological similarity coupled with the ability to produce fertile offspring by sexual reproduction. In the case of bacteria the morphological basis for comparison or separation into species is slight, and in the case of the cheese flora is reduced almost to the vanishing point; while sexual reproduction is entirely lacking in the whole bacterial group.

[1] N. Y. Agr. Exp. Sta. Buls. 203, (1901); 214, 215, 219, (1902); 231, 233, 236, 237, (1903); 245, (1904); 261, (1905); Tech. Buls. 3, (1906); 4, 5, 6, (1907).

Peculiar pathogenic power characterizes many of the forms which were early designated as species. This characteristic was serviceable both because it was easily recognizable and because it was the most important fact in connection with the organism. In the absence of some single, definite characteristic, recourse has been had to reactions to various culture media. The difficulty here encountered is that such reactions are often but an expression of the present physiological condition of the organism, this condition having been largely determined by the treatment to which the organism had been previously exposed. The examination of a large number of related species each of which is represented by a number of subcultures or strains will often furnish such a complete series of reactions that no satisfactory division into species can be made.

The initial flora of milk varies widely depending upon its environment. When this milk is made into cheese the accompanying changes in temperature, moisture and acidity induce a rapid shift in this flora. The undeveloped condition of our classification and the difficulty of keeping living cultures of many of the forms until they can be directly compared with cultures isolated at a later date have, until recently, made it practically impossible to follow this change.

When the study of germ life in any realm of nature is undertaken, attention is first concentrated upon finding media and conditions suitable for the growth of the germs present and the relative success of various efforts in this direction is measured by the number of colonies which develop. Thus the first work is quantitative. When some measure of success has been attained in this line attention is next fixed upon so modifying the conditions as to make possible the division of the germs present into groups; that is, the work becomes qualitative.

Up to 1904 our study of the bacteria in cheese was largely quantitative although we frequently isolated pure cultures and recorded their reaction upon various media. The improvements suggested by Conn & Esten[2] in the preparation of litmus gelatin, together with the beginnings of a classification which had then been made, encouraged us to undertake an intensive study both of the kinds of germs and the relative numbers in which they were present at various stages in the ripening of cheddar cheese. While the re-

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[2] Conn, H. W., and Esten, W. M. Qualitative analysis of bacteria in market milk. Conn. Agr. Exp. Sta. (Storrs) An. Rpt. 15: 63–91. 1903. See page 82.

sults from our use of litmus gelatin did not come up to our expectations the progress which has been made in the line of classification has been a constant source of encouragement.

The fact is being recognized that it is its physiological activity rather than its ancestry which makes a form distinctive. The newer systems of classification tend to emphasize this fact in a way that was difficult as long as forms were merely referred to ancestral types. The plan of Fuller & Johnson[3] and Conn's[4] first classification aimed to separate the organisms into closely related groups. The proper group to which an unknown culture belonged having been determined, there remained the problem of establishing its relation to the small number of related species which compose the group. The later work of Conn[5] arranged the germs by types, each of which received a name like that formerly applied to a species. In the classification now in process of construction by the society of American Bacteriologists the aim is to reduce cultures to physiological groups, each group and its subdivisions to be designated numerically in a manner similar to the numbering of the books in a library. Whenever convenient, the species name may be retained for its appropriate group.

From what has been said it will be evident that our present results must be looked upon as a provisional treatment of the subject. It is believed that they mark a step in advance in our knowledge of the bacteria in cheese, but nothing approaching an adequate treatment can be expected until the technique is improved to the point where a culture can be quickly and accurately assigned to its proper place in a satisfactory classification. Then examinations may be made at sufficiently short intervals to catch the various phases of the shifting panorama of germ life in the ripening cheese. Until such information is at hand regarding this important factor of cheese ripening, attempts at explaining the changes which take place in the formation of cheese will be only shrewd guesses.

ACKNOWLEDGMENTS.

It is a pleasure in this connection to acknowledge the assistance rendered by Messrs. H. E. Cook, E. L. Jones and G. Merry who

[3] Fuller, G. W., and Johnson, Geo. A., Proc. Amer. Pub. Health Asso., **25**: 580–586. 1899. Similar data in *Jour. Exp. Med.* **4**: 609–626. 1899.

[4] Conn, H. W. Classification of dairy bacteria. Conn. Agr. Exp. Sta. (Storrs) An. Rpt., **12**: 13–68. 1899.

[5] Conn, H. W., Esten, W. M. and Stocking, W. A. A classification of dairy bacteria. Conn. Agr. Exp. Sta. (Storrs) An. Rpt., **18**: 91–203. 1906.

enabled us to extend our studies to the product of their respective factories.

Our colleague, Mr. Geo. A. Smith, has materially aided us both by the preparation of experimental cheeses and by the scoring of those obtained from the above sources. This parallel study of the flora and of the commercial quality has been one of the most interesting features of this investigation and it was only made possible by the cordial assistance of Mr. Smith.

We are also deeply indebted to Dr. H. W. Conn, whose recent studies of dairy bacteria have especially fitted him to criticise these results and who has been so kind as to give us the benefit of his point of view.

HISTORICAL.

Studies of the bacteria in cheese have, uniformly, been conducted, and in most cases have been described, as incidental to the larger question of cheese ripening. At times these two questions have been considered as identical.

While the work of Duclaux[6] marks the real beginning of the attempt to sort out and arrange the germs in question, the technique at that time permitted only faint glimpses of the real situation. Solid culture media with their resulting possibilities for quantitative work and the isolation and classification of pure cultures were as yet undiscovered. It was then necessary to rely largely upon microscopic observation of liquid cultures in order to determine their purity and it was but natural that the larger motile forms should be first recognized. The minute, immotile, lactic forms which really made up the bulk of the flora were commonly overlooked.

In the absence of any exact knowledge of the species present it was natural that the workers should rely upon general deductions from the characteristics of groups of forms. Thus the analogy between the breaking down of the casein in cheese and the changes observed in milk cultures of enzym-forming bacteria led Duclaux to suggest that these forms were the cause of cheese ripening. In his opinion, the constant presence of such forms in cheese rendered the causal relation practically certain.

It should be remembered that Duclaux worked with the semisoft cantal cheese while the later studies have been made on entirely different kinds representing for the most part the various types

[6] Duclaux, E. *Ann. agron.*, 1878–1882, also Le lait, Études chimiques et microbiologiques. Paris. Baillière. 1807.

of hard cheese. It was the conclusion of Duclaux that the ripening of cheese was due to the enzyms formed by the bacteria which he had isolated. Since this was the first theory concerning the relation of bacteria to cheese ripening which rested upon any extended study of the germ content it was generally accepted as applying to all forms of cheese and must still be considered as one of the current theories on the subject.

Taking advantage of solid media Adametz[7] in 1889 reported upon the bacteria of emmenthaler cheese and "Hauskase." His observation that the larger part of the germs present decomposed sugar with the formation of acid laid the foundation for the theory that the bacteria of the acid-forming group were responsible for the ripening changes in cheese.

Here, again, the inability to treat the subject upon the basis of species forced the classification back to that of general groups. The selection of acid formation as a group characteristic in this case was unfortunate; as the work of Smith[8] and others has shown that in the presence of sugar practically all bacteria form acid, the apparent variation in its formation being largely due to a simultaneous production of other neutralizing compounds.

For nearly twenty years the students of this subject have been divided into two camps, one holding that cheese-ripening is due to the enzym-forming bacteria, the other that it is due to the acid-forming group. During this time neither camp has succeeded in demonstrating that its view is right or that the other is wrong. Von Freudenreich[9] has been the leading exponent of the lactic-acid theory while Adametz[10] and Weigmann[11] have led in the support of the theory of bacterial enzyms. During this controversy the study of the flora consisted mainly in a quantitative determination of the numbers of each of these two large groups at various stages in the ripening process, supplemented by studies of the physiological activity of representatives of each group. Thus von Freudenreich[12] showed that lactic-acid bacteria could render casein

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[7] Adametz, L. Bakteriologische Untersuchungen über den Reifungsprozess der Käse. *Land. Jahrb.*, **18**: 227–270. 1889.

[8] Smith, Theo. Ueber die Bedeutung des Zuckers im Kulturmedien für Bakterien. *Cent. Bakt.*, I Abt; **18**: 1–9. 1895.

[9] v. Freudenreich, Ed. Ueber die Erreger der Reifung bei dem Emmenthaler Käse. *Cent. Bakt.*, II Abt, **3**: 231–235. 1897.

[10] Adametz, L. Sind Milchsäurebakterien oder Tyrothrixarten die Erreger von Reifung und Aroma beim Emmenthalerkäse? *Milch Ztg.*, **29**: 753–754. 1900.

[11] Weigmann, H. Handbuch der technischen Mykologie, **2**: 168. 1906.

[12] See note 9.

soluble in the presence of chalk, and he and Russell & Weinzirl[13] made experimental cheeses to which they added starters of various organisms. These and other investigators have attempted to work out the flora more in detail but the methods at their disposal were not equal to the task.

Gradually it is coming to be recognized that representatives of both of these bacterial groups may function in the ripening processes. Gorini[14] has pointed out that the division between enzym-forming and acid-forming bacteria is not clear cut but that there are many bacterial forms in cheese which produce appreciable quantities of both acid and enzyms. He has striven to show that the group having these two characteristics in common is particularly important.

This bulletin marks the application of an improved technique to this complex question and it is believed that it thereby furnishes more exact and detailed information regarding the bacterial life of the cheese than has been given by previous workers.

CHEESES STUDIED.

KIND.

As we intended to study the flora of cheddar cheese, all of the cheeses used were good examples of full cream American cheddar and were made in accordance with the approved methods by experienced makers. As they ripened they proved to be of very high quality, being practically free from any unusual flavors or other defects.

The cheeses VIII and X were pressed in the form of Young Americas, each weighing about 10 pounds; while the remainder were what is termed "flats," ranging in weight from 32 to 40 pounds. Our object in working with these large cheeses was to have a mass sufficiently large to ripen normally in spite of repeated sampling.

ORIGIN.

In order that these cheeses should represent more than the flora of our own dairy we obtained cheese from four commercial factories, all of which are characterized by a very fine product. Cheeses

[13] Russell, H. L. and Weinzirl, J. The rise and fall of bacteria in cheddar cheese. *Cent. Bakt.*, II Abt, 3: 456–467. 1897.

[14] Gorini, C. Ueber die säure labbildenden Bakterien der Milch. *Cent. Bakt.*, II Abt., 8: 137–140. 1902.

I, III and IV were furnished by Mr. H. E. Cook from the factory at Denmark, and cheese II from the factory at Copenhagen, cheeses V and IX by Mr. G. Merry from Verona, cheese VII by Mr. E. L. Jones from Delevan, while cheeses VIII and X were made by our Dairy Expert in our own dairy.

RIPENING CONDITIONS.

The factory-made cheeses were shipped to us by express, usually as soon as they were taken from the press, but in a few cases they were subjected to a slight delay. They were dipped in hot paraffin before they were placed in our curing room.

The curing room was cooled by the ammonia process and the temperature regulated automatically with a daily fluctuation of about 3 degrees F. under favorable conditions. Owing to accidents to the machinery the temperature varied considerably with some of the cheeses. The temperature of ripening is accordingly given in connection with each cheese.

TECHNIQUE OF INVESTIGATION.

TAKING SAMPLES.

Samples for analysis were taken when the cheese was ready to go into the curing room and thereafter at stated intervals. In taking a sample a square inch of the layer of paraffin and the rind was first removed with a sterile knife, then a plug about four inches in length was drawn with a carefully flamed and cooled cheese tryer. Von Freudenreich and Harrison and Connell[15] have shown that the bacteria are not evenly distributed in the different layers of the cheese and in order to get a representative sample we have followed the suggestion of Harrison & Connell and used a number of thin slices from the different parts of the plug. One gram of these slices was weighed out on a flamed copper foil, using a sensitive balance. The sample was then triturated in a flamed mortar with 10 grams of sterile granulated sugar or finely ground sterilized quartz. Sugar was used with the first five cheeses and quartz with the others. Sugar is preferable in that it goes into solution when the ground mass is diluted with water, thereby facilitating the transfer of representative portions to the plates. This same property

[15] Harrison, F. C. and Connell, W. T. A comparison of the bacterial content of cheese cured at different temperatures. *Cent. Bakt.*, II Abt., 11: 637-657. 1903.

renders it less efficient as a grinding medium in the case of new cheese which is both very tough and high in moisture. Here the quartz is decidedly preferable. As the cheese becomes older it softens and then can be ground much better with sugar than with quartz. Care was taken to have the room in which the work was done as free from dust as possible and all utensils coming in contact with the cheese were either sterilized in the ordinary way or their surfaces were carefully flamed over a bunsen burner. There remains the objection that the material was exposed to the air for some minutes during the weighing and grinding. At most, the germs falling from the air were not numerous and with the high dilution necessitated by the germ content of the cheese there was slight chance of more than a single germ from the air appearing on any of the plates. In selecting colonies for further study only those were taken which represented two or more colonies on the plate. Thus we feel fairly certain that the germs to be later described represent forms which were present in the cheese when the sample was taken.

It is a matter of common observation that cheeses which are sampled often do not ripen normally, due largely to the loss of moisture and the introduction of molds. Our method of overcoming this objection to frequent sampling was to fill the place from which the plug had just been taken with melted paraffin. While the heat from this paraffin slightly affected the texture of the cheese at the surface of the hole, plugs later drawn from the immediate vicinity showed no bad effects either in texture or flavor. The paraffin entirely prevented the entrance of molds.

DILUTIONS.

The sample of freshly ground cheese was diluted with 30 cc. of sterile distilled water. This water was added gradually toward the close of the grinding process and the aim was to form an emulsion. The success in making a good emulsion varied with the age of the cheese, it being difficult to produce with a young cheese and easy with an old one. A measured amount of the emulsion was quickly transferred to a water blank from which the desired dilution was prepared.

In calculating the dilution of cheese sampled in this manner two methods are in use. According to one method the dilution is computed solely on the basis of the volume of water added in the grinding process while according to the other the proportionate

amount added to a plate is figured on the basis of the total volume present at the end of the grinding process. The former method is the more convenient as the dilution factor can be figured in advance and the dilution is always expressed in round numbers. According to the second method the actual volume of the emulsion is determined and this value used in the computation. In our work we followed the latter method and as the average determined volume of the emulsion, when 30 cc. of water had been added, was 33 cc., our numerical results are 10 per ct. higher than they would have been if calculated on the other basis.

Green cheese has a very large germ content, one of those studied showing 178 millions per gram. As the cheese ripens the germ content diminishes until in a ripe cheese only a few thousand per gram may be found. In order to get a good development of the colonies and thereby assist in the provisional separation into kinds of germs present there should be only a few hundred colonies on a plate. Accordingly, the amount of dilution is of considerable importance. It has been the practice in this work to make at least six dilutions ranging from 1–1000 to 1–200000 and three sets of such dilutions, 18 plates, were made from each sample.

While these high dilutions provide for the formation of characteristic colonies they have the disadvantage of cutting out those forms which are present in the cheese in comparatively small numbers. The occasional representative of these scattering forms which appear upon the plates can not be distinguished with certainty from the occasional isolated colony brought in accidentally from the air, and is accordingly rejected. There seems to be no satisfactory remedy for this difficulty since with less dilution these forms are either crowded out or are overlooked on account of the small size of the colonies on heavily seeded plates. A partial remedy is found for certain classes where special treatment reduces the competition; as where the material is heated to kill all but the spores, sugar is omitted to discourage the acid formers or sufficient acid is added to inhibit all but the yeasts.

MEDIA.

One of the most striking characteristics of the majority of the germs from cheese is the feebleness with which they grow on ordinary solid culture media. In fact advance in our knowledge of the cheese flora is closely associated with improvement in the preparation of media for such study. Thus far no one has found a medium upon which all of the forms present would develop satis-

factorily and simultaneously. Accordingly we have been compelled to use a number of media.

Our quantitative determinations were largely made upon whey-litmus gelatin. More colonies developed from cheese samples on this medium than on the standard lactose gelatin. By its use most of the acid-forming bacteria can be distinguished from those that do not have this power. We did not observe that the litmus in this medium had any influence on the size, shape or structure of the colonies. In some cases it was observed that the color of some of the chromogenic bacteria tended to be obscured by the color of the litmus. A sugar-free medium was employed when searching for the liquefiers and non-acid-formers since many of these are sensitive to the acid which is developed from sugar in the medium by the lactic germs. Most yeasts thrive on cane sugar and tolerate an acid reaction so strong as to inhibit bacteria. From some of the cheeses we inoculated a series of plates of cane sugar media and added from 1 to 6 drops of a 25 per ct. tartaric acid solution to each plate at the time it was poured. For the sake of brevity and exactness the composition of these various media is summarized as follows:

MEDIA USED IN INVESTIGATION.

Laboratory number.	Composition of the media.	Reaction.
2.00	5 grams Beef extract (Liebig's) 5 " Na Cl 10 " Peptone (Witte's) 100 " Gelatin 1000 cc Water (distilled)	*Per cent.* 1.5 normal acid to phenolphthalein.
2.02	5 grams Beef extract (Liebig's) 5 " Na Cl 10 " Peptone (Witte's) 100 " Gelatin 1000 cc Water (distilled)	Neutral to phenolphthalein.
2.22	5 grams Beef extract (Liebig's) 10 " Peptone (Witte's) 280 " Gelatin 1000 cc Water (distilled) 1000 " Whey	1.5 normal acid to phenolphthalein.
	100 grams Litmus cubes } filtrate 500 cc Water (distilled) }	1.5 normal acid to phenolphthalein.
2.31	5 grams Beef extract (Liebig's) 5 " Na Cl 10 " Peptone (Witte's) 120 " Gelatin 20 " Cane sugar 1000 cc Water (distilled)	Reaction not adjusted.
3.00	5 grams Beef extract (Liebig's) 5 " Na Cl 10 " Peptone (Witte's) 15 " Agar 1000 cc Water (distilled)	1.5 normal acid to phenolphthalein.

The plan of denot ng the different media by numbers has been found useful in both laboratory work and in records and will be followed in this publication. In this media record the digit signifies the form of medium as bouillon, gelatin or agar. The first decimal place gives the kind of sugar employed and the second decimal place is left for other variations. Thus 2.00 signifies the plain peptone gelatin, 2.30 the same medium with the addition of cane sugar while 2.31 is used for the latter medium when made without adjusting the reaction.

We have followed the suggestions of the committee on standard methods of the American Public Health Association[16] as reported in 1904 in the preparation of our media except that we have uniformly used Liebig's beef extract and sodium chloride and unless otherwise stated have titrated to a standard reaction of + 1.5 per ct., that is of 15 cc. normal acid to the litre. Titrations were made with hot solutions using N/10 sodium hydroxide and phenolphthalein.

Medium 2.22.— This is our plain peptone gelatin. It was rarely employed except to test liquefaction in the work of classification.

Medium 2.02.— This differed from the above medium only in its reaction, being made neutral. We used it for plating out cheese samples when studying the liquefiers and non-acid-producing bacteria.

Medium 2.22.— This was the principal medium used for both quantitative and differential study. In preparing plates with medium 2.22 each plate received 1 cc. of the cheese emulsion, 1 cc. of the litmus solution and 8 cc. of the whey gelatin. The plate accordingly contained approximately 11 per ct. gelatin.

Preparation of the whey.— Three hundred cc. of sour milk was mixed with 10 litres of fresh, skimmed milk and the mass coagulated with 5 cc. of rennet extract. The coagulum was cut up finely and allowed to stand 1 hour. After being drained off and sterilized the whey was ready for use.

Preparation of the litmus solution.— One hundred grams of dry litmus cubes was added to 500 cc. of distilled water. This was held 24 hours at 37° C. after which it was filtered and the reaction of the filtrate adjusted to + 1.5 per ct. after the method suggested by Conn & Esten.[17] This litmus solution was sterilized in test tubes for 30 minutes in the steamer on three successive days.

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[16] Report of the Committee on Standard Methods of Water Analysis to the laboratory section of the Amer. Pub. Health Asso. *Journal of Infectious Diseases.* Supplement No. 1, May, 1905.

[17] See note 2.

Medium 2.31.— This was the medium used in isolation of yeasts.

Medium 3.00.— This is our plain peptone agar and like 2.00 was little used in these studies.

COUNTING.

The plates made as above described were ordinarily held ten days in the laboratory before counting. The temperature approximated 70° F. (21° C.) but varied 10 degrees from this at different seasons of the year. The average of the numbers found on the plates at the end of ten days was taken as the germ content of the cheese at the date of sampling. The counting was done with a hand lens magnifying 4 diameters and in most cases the entire number on the plate was enumerated but where the numbers present were excessive the counting was restricted to ten square centimeters or in some few instances was done under the microscope using a magnification of 10 to 20 diameters. The ease and accuracy of the hand counting was increased by using a glass plate ruled in square centimeters and fractions as a guide and by an automatic recorder for enumerating the colonies. After the plates had been counted for total numbers they were recounted to find the number of each of the types of colonies represented.

DIFFERENTIATION OF TYPES.

The colonies on the plates were studied with a view of recognizing and isolating all the different types of germs. This differentiation of bacteria by means of the colony growths on the gelatin plates was one of the most important parts of our work. Solid media, gelatin in particular, are universally used by bacteriologists for differential study. While the gelatin medium is a great improvement over the liquid media used by Duclaux in his cheese investigations, it has its limitations.

A large number of forms necessarily find their way into the milk during its collection and its manufacture into cheese and they develop there at different rates depending on how well they are adapted to the conditions which prevail. When a sample of the cheese is plated it is probable that not all of the classes of germs present will be represented by colonies on the plate owing to the dilution used. In this work the dilutions in each cheese ranged from 1-1000 to 1-200000. The kinds present in the cheese in num-

bers per gram approximating less than the above dilution would usually be overlooked.

The differentiation of those bacteria that develop colonies on the gelatin plates is based on their production of acid, of liquifying enzym or of some characteristic appearance in the colony peculiar to the particular type of organism.

It is fairly easy to separate the acid-producers from those that do not possess that power. This may be done by the addition of calcium carbonate or litmus to the gelatin. We used litmus in our work. The litmus must be sensitive, otherwise the weak acid-producers may not be recognized. The condition of the organisms at the time of plating the sample also seems to affect the results. An illustration of this is found in the case of old cheese. Many of the lactic organisms become weakened after the cheese has been in the curing room for three or four months. When a sample is plated from such cheese these organisms often fail to develop enough acid to turn the litmus red.

The separation on the basis of the liquefication of gelatin is a fairly accurate method but the group classed as slow liquefiers may be often overlooked. The ability of the liquefiers to produce proteolytic enzyms is subject to variations which are not yet fully understood. The presence of sugar impedes the liquefaction and slight variations in the composition or reaction of the media may entirely inhibit it.

After all the colonies had been separated into four classes by means of the acid production and liquefaction further subdivision was necessarily based upon differences in size, shape, structure and color. These latter characteristics are subject to greater variation than either the acid production or the liquefaction, so that here the personal equation was necessarily large. In order to reduce the danger of missing any species present on the plate our aim was to recognize more types than were present, the recognition being based on very slight variations such as may be found among colonies on a plate prepared from a pure culture. We checked the possibility of including different species under a single head by isolating two or more pure cultures of each provisional group, and relied upon the system of classification, to be later described, to determine the duplicates. While we recognize the limitations of separating bacteria into species by means of the methods mentioned above we feel fairly certain that we missed very few important species of bacteria among those that developed on the plates.

CLASSIFICATION.

A convenient and rapid method of reducing unknown cultures to clear-cut and closely related groups is the end toward which bacteriologists are striving. The more nearly these groups approximate our present conception of species the better.

An attempt at classifying dairy bacteria was made in 1899 by Conn.[18] He separated them into 10 groups, 3 of which were characterized by their chromogenesis — red, orange and yellow forms. The remaining organisms were divided into 7 groups on the basis of their morphology, liquefaction and spore formation. These characteristics could be quickly determined (in many cases the assignment to groups could be made from the original plates) but owing to the small number of groups the final problem of classifying the members of a group was not an easy one.

In 1906 Conn[19] brought out a more detailed classification of dairy bacteria which recognized 115 groups and about 160 types. In this connection he disavowed any attempt to make use of the term species. This publication marked a distinct advance in the knowledge of the subject and it has been of much assistance to us in our study of the cheese flora. The described types cover the field so completely that among the large number of cultures isolated in connection with our present study all but one were included in Conn's list.

The principal criticism of his system as it now stands is that many of the types are too inclusive. Our accumulation of cultures of a single type in one case amounted to nearly 100 and they naturally fell into a number of subtypes. Even with a much smaller number of cultures well marked differences were observable. One type, *Micrococcus varians*, is well named; since the seven cultures which were studied are distributed among four different group numbers. Exception might also be taken to some of the characteristics used in separating groups. Viscosity, character of colony growths, and the character of the curd produced in milk seem to us as most open to the objection that discordant results would probably be obtained by different workers.

Conn's classification is an adaptation to bacteria of the conventional botanical description accompanied by a key quite similar to that in Gray's Manual. Simultaneously there has been taking form

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[18] See note 4.

[19] See note 5.

a system which is an adaptation of the Dewey system of classifying books, printed upon cards. It is an answer to the imperative need which has been felt of a means by which a rapid comparison can be readily made between cultures.

Fuller & Johnson[20] showed that the most stable characteristic of cultures of water bacteria could be conveniently printed upon a card and the reaction of given cultures indicated by + or — as the facts required. Conn adopted this method in connection with his first work upon dairy bacteria, extending somewhat the list of reactions there recorded.

Gage & Phelps[21] markedly extended the range of the card record. they added an ingenious plan of expressing numerically the reaction of the organism under groups of conditions so that 91 possible reactions were recorded under 15 headings. At the same time, in connection with Kendall,[22] they introduced the use of group numbers which expressed the most important characteristics of the cultures in a form which permitted the orderly arrangement of the cards and the quick finding of duplicates.

Kendall proposed a numerical system of recording the minute details of culture growths. This extension in the matter of detail before there is agreement as to which are the more important culture differences simply increases confusion in the present state of the science. The time will undoubtedly come when this plan will be found useful in recording the influence of environment upon the details of culture growth.

Recognizing the value of these attempts at bringing order out of chaos the Society of American Bacteriologists appointed a committee to draw up a card which should embody the maximum number of good features. This committee reported at the Ann Arbor meeting in 1905 and the New York meeting in 1906 and presented a card which the Society adopted provisionally. The committee was retained with instructions to improve the card as opportunity offered. An improved card was presented and adopted at the Chicago meeting in 1907.

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[20] See note 3.

[21] Gage, S. DeM. and Phelps, E. B. On the classificaton and identification of bacteria with a description of the card system in use at the Lawrence Experiment Station for records of species. Proc. Amer. Pub. Health Asso. **28**: 494-505. 1903.

[22] Kendall, A. I. A proposed classification and method of graphical tabulation of the characters of bacteria. Proc. Amer. Pub. Health Asso. **28**: 481-493. 1903.

A NUMERICAL SYSTEM OF RECORDING THE SALIENT CHARACTERS OF AN ORGANISM.

Group number	
100	Endospores produced
200.	Endospores not produced
10.	Aerobic (Strict)
20.	Facultative anaerobic
30.	Anaerobic (Strict)
1.	Gelatin liquefied
2.	Gelatin not liquefied
0.1	Acid and gas from dextrose
0.2	Acid without gas from dextrose
0.3	No acid from dextrose
0.4*	No growth with dextrose
.01	Acid and gas from lactose
.02	Acid without gas from lactose
.03	No acid from lactose
.04*	No growth with lactose
.001	Acid and gas from saccharose
.002	Acid without gas from saccharose
.003	No acid from saccharose
.004*	No growth with saccharose
.0001	Nitrates reduced with evolution of gas
.0002	Nitrates not reduced
.0003*	Nitrates reduced without gas formation
.00001	Fluorescent
.00002	Violet chromogens
.00003	Blue "
.00004	Green "
.00005	Yellow "
.00006	Orange "
.00007	Red "
.00008	Brown "
.00009	Pink "
.00000	Non-chromogenic
.000001*	Diastasic action on potato starch, strong
.000002*	Diastasic action on potato starch, feeble
.000003*	Diastasic action on potato starch, absent
.0000001*	Acid and gas from glycerine
.0000002*	Acid without gas from glycerine
.0000003*	No acid from glycerine
.0000004*	No growth with glycerine

The genus according to the system of Migula is given its proper symbol which precedes the number thus:

BACILLUS COLI (Esch.) Mig.	becomes	B.	222.111102
BACILLUS ALCALIGENES Petr.	"	B.	212.333102
PSEUDOMONAS CAMPESTRIS (Pam.) Sm.	"	Ps.	211.333151
BACTERIUM SUICIDA Mig.	"	Bact.	222.232"03

*These items were added to the group number in 1907 and have not been used by us in this work.

This card consists of three essential parts: (1) A group number (see p. 64) as suggested by Gage, which records the more important facts regarding an organism and provides a means of arranging the records so that duplicates can be found readily; (2) a brief characterization (see page 116) which may be filled in by means of + or — as suggested by Fuller and Johnson and which serves as a further means of comparing germs with the same group number; and (3) a provision for tersely recording the detailed features of cultures upon the common media as suggested by Chester.[23]

The significance of each figure in the group number as endorsed by the Society of American Bacteriologists at its annual meeting in December, 1907, is shown by the key given on the opposite page.

Our records of the cheese flora were begun with Conn's modification of Fuller and Johnson's table but were largely entered upon a card prepared by Conn as a modification of Gage's card. This card furnished practically all of the data called for by the Society card of 1906 aside from the detailed features of the culture growths. As soon as the Society cards were available in 1906 the work was continued with them and the records transferred from the other cards. The Society card of 1907 appeared too recently to be utilized in this study. However it differed from the former card mainly in calling for additional items and in an extension of the group number as indicated above. While the lack of some of the data for this Society card is regrettable sufficient are at hand to characterize the cultures to an unusual extent.

As has been explained, pure cultures were obtained from two or more colonies representing each type present on the plates at each analysis. The purity of these cultures was first tested and their group number determined except that relating to lactose and saccharose. At this point cultures which gave every appearance of being duplicates were rejected and further studies confined to a single representative of each type. These selected cultures were tested with regard to practically all of the points called for by the classification card.

In the presentation of our results it has seemed best to follow the Society card in designating the types of germs present. Accordingly, in the discussion of the individual cheeses the germs will be referred to by their group number and additional data regarding them

[23] Chester, F. D. A manual of determinative bacteriology. New York: Macmillan. 1901.

will be presented in the table on page 116. As an assistance in comparing our results with those of earlier workers the name of the organism according to the classification of Conn is also given. This double presentation serves to bring out the advantages and limitations of both systems of nomenclature.

DETAILED STUDIES OF CHEESES.

CHEESE 4.6 I.

This study of the cheese flora was begun with Cheese 4.6 I which was made January 23, 1904, at the Crown Brand Factory, Denmark, N. Y., and arrived in our laboratory four days later. A sample for analysis was taken immediately and the cheese was dipped in hot paraffin and placed in the curing room at approximately 60° F. (15.5° C.). This 40 lb. cheese was under observation 136 days, 12 samples being taken during that period. It was a good example of cheddar cheese made for home trade and when fully ripened from the commercial point of view at 60 days scored 97½.

All of the samples were plated upon medium 2.22 but for comparison plates were also made upon media 2.00, 2.20 and 3.20. The highest counts were uniformly obtained upon 2.22 and the other media did not seem to offer any additional advantages.

Qualitative flora.— In this first cheese attention was concentrated upon becoming familiar with the colony appearance of each species present and no special attempt was made to determine the relative numbers of the different species in each sample. Representatives of each observed variation in colony growth were isolated from each sample and after their purity had been determined they were studied both morphologically and culturally. Thus from the sample of April 7 eighteen cultures were isolated and after the preliminary examination all but five were rejected as being duplicates of some of these five. When the study of these five was completed two of them were found to have the same type name and group number. In all, 95 pure cultures from this cheese were studied, of which 27 were classified upon the cards, the remainder being rejected as duplicates.

The group number according to the Society card of 1906 and the type name according to Conn as well as the age of the cheese at which each of these 27 cultures were isolated are given in Table I.

TABLE I.—GERMS FOUND IN CHEESE 46 I.

Group number.	Type name (Conn).	AGE OF THE CHEESE IN DAYS.							
		7	23	34	47	61	75	89	136
B. 112.33320	*B. lactis nebulus*	+ +	+	....	....	....	....	....	....
Bact. 122.22200	*Bact. lactis ubiquitum*	....	....	....	....	....	....	+	....
Bact. 212.22200	*Bact. lactis acidi*	....	....	....	....	....	....	....	+
Bact. 212.22300	*Bact. lactis acidi*	....	....	....	....	....	....	....	+
M. 212.33305	*M. lactis citreus B*	....	....	....	....	....	+	....	....
Bact. 221.22200	*Bact. lactis brevis*	....	....	+	....	....	+	....	....
Bact. 222.22200	*Bact. lactis acidi*	....	....	....	+	+ +	+ +	+ +	....
Bact. 222.22220	*Bact. lactis acidi*	....	+	....	....	....	....	....	....
Bact. 222.22300	*Bact. lactis acidi*	....	....	+	+	+	+	+	....
Bact. 222.22320	*Bact. lactis acidi*	....	+ + +	+	....	....	....	....	....

The sign + in the above table marks the isolation of a culture of the given group number and type name. In a number of cases two or more of these signs are given on a single date. These indicate cultures in which slight differences were noted in the preliminary study but an extended examination did not show them sufficiently different to affect either the group number or the type name.

It will be noted in this and in the succeeding cheeses that two or more group numbers are used for representatives of the type *Bact. lactis acidi*. Those marked 212. do not produce turbidity in the closed arm of the fermentation tube in the presence of dextrose, lactose or saccharose while those marked 222. do produce turbidity under similar conditions. This formation of turbidity has been taken as a convenient though arbitrary basis for dividing the aerobic from the facultative forms. The accuracy of this basis for division is open to question. Germs marked .222 form acid from dextrose, lactose and saccharose without the formation of noticeable amounts of gas while those marked .223 differ in not forming acid from saccharose.

In nearly all cases the fourth decimal place is given as zero. In any place a zero means that the data is lacking, except in the fifth decimal place where it signifies that the growth is white. This lack of data is due to the fact that indol formation and not nitrate reduction entered into the group number on the cards in use when the majority of the cheeses were studied. In all of the numerous instances where the nitrate reduction of *Bact. lactis acidi* has been tested nitrates were not reduced and there is a high degree of probability that 2 should be inserted in all cases in the fourth decimal place of its group number.

The differences in the fermentation of sugar and in the relation of oxygen to growth probably indicate constant and important differences which may be profitably used in subdividing the type *Bact. lactis acidi*. Well developed colonies show differences by means of which the appropriate group number can often be inferred but in the smaller colonies as they ordinarily appear on the plates these distinguishing characteristics are faint or lacking. A further improvement in our media-making is a necessary antecedent to an accurate enumeration of each class of *Bact. lactis acidi* appearing upon the plates.

Quantitative results.— The quantitative determinations were made upon medium 2.22 with plates which had been held from 7 to 10 days at 65° to 70° F. Six or more plates were made upon this medium at each examination and the recorded numbers are the averages of the resulting counts.

In addition to the germ content Table II records the observations made by Mr. Smith upon the physical condition of the cheese at each analysis as well as the commercial score assigned to it. This score was upon the basis of flavor 50, texture 25, color 15 and package 10 points.

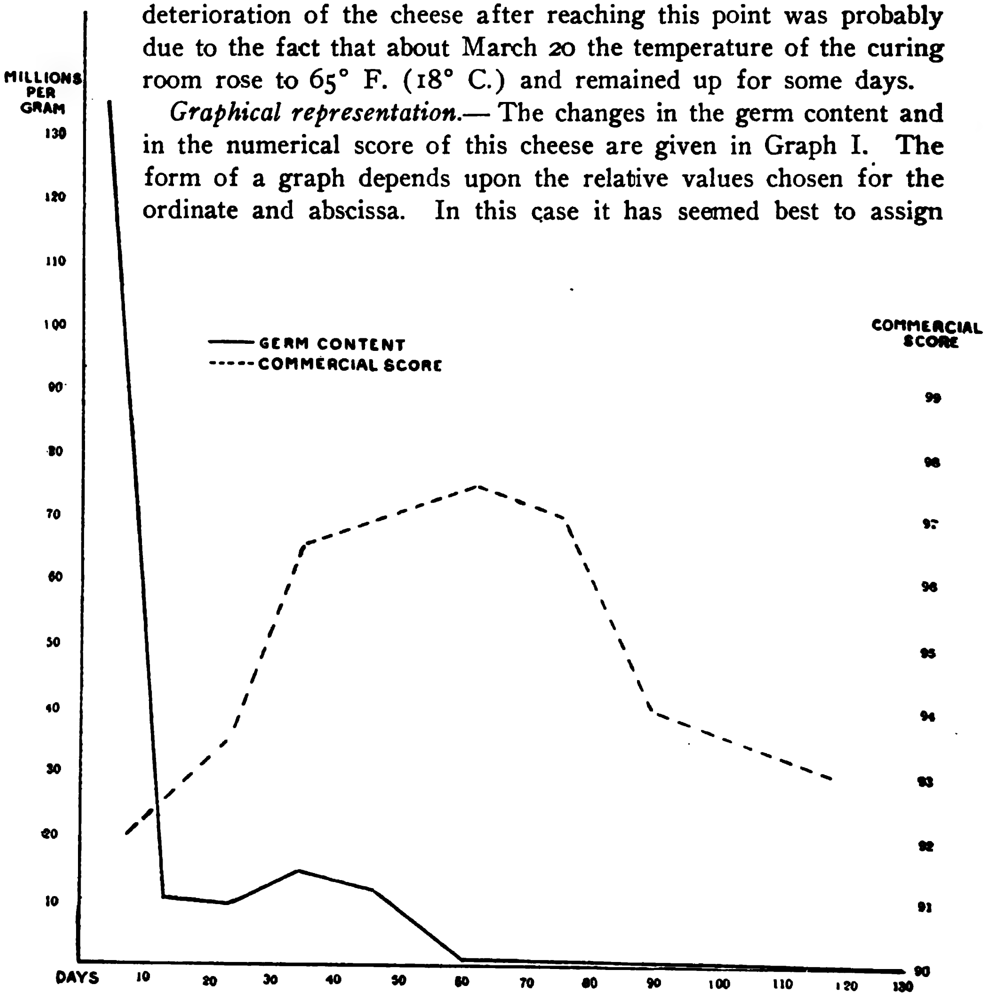
TABLE II.—GERM CONTENT AND PHYSICAL CONDITION OF CHEESE 4.6 I.

Sample taken	Age of cheese.	Germs.	Flavor.	Texture.	Body.	Color.	Score.
	Days.	*Per gram.*					
Jan. 27	4	135,700,000					
" 30	7	Plates lost	No flavor except acid	Curdy	Close, some mechanical holes	Slightly mottled	92.
Feb. 5	13	10,400,000					
" 15	23	9,400,000	Acid decreasing; slight cheese flavor	Somewhat stiff	Close, small mechanical holes	Little mottled	93.5
" 26	34	14,000,000	Acid nearly gone; some cheese flavor	Smooth	Close, few mechanical holes	Slightly streaked	69.5
Mar. 10	47	8,800,000	Traces of acid; low cheese flavor	Smooth; slightly waxy	...	Slightly streaked	97.
" 24	61	850,000	Acid practically gone low, clean flavor	Silky	Mechanical holes closed up	Almost perfect	97.5
April 7	75	550,000	High and a little sharp	Smooth and silky	Slightly soft	...	97
" 21	89	340,000	Sharp	Slightly salvy			
May 19	117	...	Shary, slightly off	Waxy	Close	...	94.
June 7	136	38,000	...	...	...	...	93.

The highest number of germs per gram of cheese, 135 million, was found in the first sample when the cheese was 4 days old. At 13 days the number had dropped to 10 millions. It was practically at this figure at 47 days but at 61 days it had fallen to slightly less than 1 million and steadily decreased after that date.

It will be noted that the true cheese flavor was barely appreciable at 23 days but was well developed at 61 days. The score likewise reached its maximum and the cheese was ripe when there was approximately 1 million living germs per gram of cheese. The rapid deterioration of the cheese after reaching this point was probably due to the fact that about March 20 the temperature of the curing room rose to 65° F. (18° C.) and remained up for some days.

Graphical representation.— The changes in the germ content and in the numerical score of this cheese are given in Graph I. The form of a graph depends upon the relative values chosen for the ordinate and abscissa. In this case it has seemed best to assign



GRAPH I.— GERM CONTENT AND COMMERCIAL QUALITY OF CHEESE 4.6 I.

equal space to 1 million germs per gram on the ordinate and 1 day on the abscissa. The commercial score has been shown by giving 0.1 of a point in the score the same value on the ordinate as 1 day on the abscissa.

In order to keep the graph within the limits of a page the space allotted to a million germs is small. On this account one gains the impression from Graph I that the germs had practically disappeared by the time the cheese was ripe at 61 days. There were then present approximately 1 million living germs per gram, which is a very considerable number.

The graph of the commercial score brings out prominently the commercial rating of the cheese. It gained rapidly in quality up to 61 days when it was commercially ripe. After that point its value declined sharply.

CHEESE 4.6 II.

This 30 lb. cheese was made at Copenhagen, N. Y., April 22, 1904, and reached our laboratory April 26. It was dipped in hot paraffin and held at 65° to 70° F. (18° to 21° C.) until June 10 after which it was kept at 60° F. (15.5° C.). Nine samples were taken between April 26 and June 30 and the analyses were made according to the methods employed with cheese 4.6 I. On June 30 the cheese was disposed of. It was overripe and had developed a slightly bitter flavor.

Qualitative flora.— In this as in cheese 4.6 I which was being studied during a portion of the same period the work was directed toward isolating cultures of all the species present at each examination. Fifty-five cultures were isolated and studied sufficiently to indicate duplicates, and 19 representative cultures were classified upon the cards. The details of the isolation of these 19 cultures are given in Table III.

TABLE III.— GERMS FOUND IN CHEESE 4.6 II.

Group number.	Type name (Conn).	AGE OF CHEESE IN DAYS.								
		4	17	20	27	34	41	48	55	69
M. 211.33305	*M. lactis aureus A*....	+	....	....	....	....	....	....	..	..
M. 212.33300	*Galactococcus versicolor*	......	+	....	....	....	....	....	..	..
Bact. 222.22200	*Bact. lactis acidi*......	+ + +	+ + + +	+ +	+	+ +	+	+ +	+	+

In the study of the flora of this cheese a vigorous effort was made to find a basis for subdividing the type *Bact. lactis acidi* which

made up practically the entire flora of this cheese. In spite of the extended study of a large number of cultures the resulting group number and type name were uniform for all.

The two forms of micrococci found in this cheese were not observed in connection with Cheese 4.6 I.

The great difference in the flora of Cheeses 4.6 I and 4.6 II, which have only Bact. 222.22200 in common, is especially interesting in view of the fact that the Denmark and Copenhagen factories are located but a few miles apart and there was an interval of only three months between the dates of making.

Quanitative results.—The quantitative results as given in Table IV were obtained from plates on medium 2.22 under conditions similar to those given for Cheese 4.6 I. The physical examination and commercial rating were made by Mr. Smith.

TABLE IV.—GERM CONTENT AND PHYSICAL CONDITION OF CHEESE 4.6 II.

Sample taken.	Age of cheese.	Germs.	Flavor.	Texture.	Body.	Color.	Score.
	Days.	*Per gram.*					
Apr. 26	4	69,600,000	Pairly clean acid; no cheese flavor......	Curdy and stiff......	Close..	Wavy....	92
May 9	17	15,000,000	Clean acid flavor;* no cheese flavor......	Stiff but well broken down	" ..	Streaked.	94½
" 12	20	3,100,000	Slight acid; faint objectionable flavor..	Smooth, slightly curdy....	" ..	Slightly wavy...	94½
" 19	27	2,100,000	Beginnings of clean cheese flavor......	Smooth and waxy....	" ..	Straight..	94½
" 26	34	1,100,000	Faint acid and low cheese flavor......	Smooth....	" ..	"	94½
June 2	41	1,800,000	....	....	......	....	....
" 9	48	1,500,000	....	....	......	....	....
" 30	69	36,000	Slightly bitter.......	Smooth and waxy....	" ..	"	90½

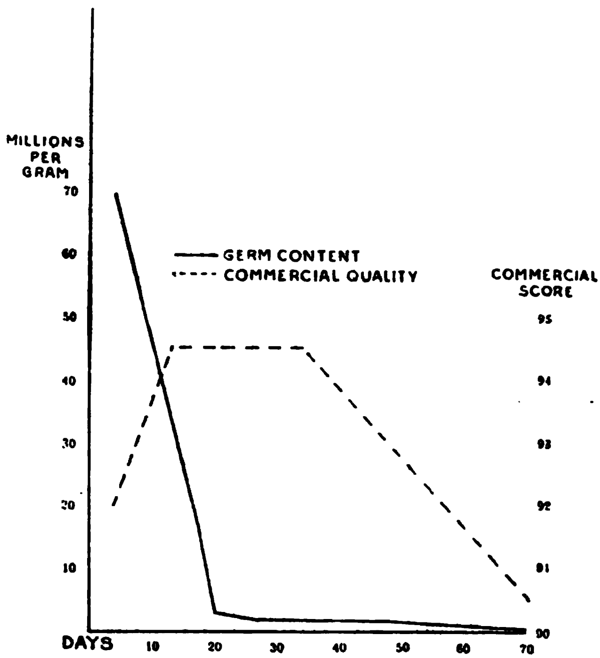
*The physical examination was held on May 5.

Two mishaps occurred in connection with these examinations. The plates made upon May 5 and on June 19 were lost on account of the melting of the gelatin. Additional plates were prepared on May 9 and the results from these are given in the table.

The germ content of this cheese at 4 days was reasonably high, 70 millions per gram, but it dropped steadily to approximately 3 millions at 20 days and then decreased more slowly.

The rapid ripening of this cheese as well as the trace of bitter flavor and the relatively low score when ripened are undoubtedly

due to its having been held at too high a temperature during the ripening period. It will be noted that the true cheese flavor was observed when the cheese was 27 days old and that it was fairly developed at the end of 34 days. The point where the cheese could be considered commercially ripe was probably at 41 or 48 days but unfortunately it was not scored at those dates. The germ content was approximately 1.5 millions per gram at 48 days.



GRAPH II.— GERM CONTENT AND COMMERCIAL QUALITY OF CHEESE 4.6 II.

Graphical representation.— The changes in the germ content and in the commercial score are shown in Graph II on the same scale as used in Graph I.

The decrease in the germ content during the first 20 days is very abrupt. The highest commercial quality is also obtained before the 30th day after which the quality of the cheese is rapidly impaired. The rapidity of these changes was probably due to the relatively high temperature, 65° to 70° F. (18° to 21° C.), at which this cheese was ripened.

CHEESE 4.6 III.

This 40 lb. cheese. like Cheese 4.6 I, came from Crown Brand factory. It was made August 1, 1904, and arrived at our laboratory and was first sampled on August 3. It was dipped in hot paraffin and cured at 60° F. (15.5° C.). The cheese was cut up when 58 days old. It then had a fine but slightly pungent flavor, being slightly over-ripe.

Beginning with this cheese the method of analysis was modified as follows: Three separate series of plates were made from each sample. One series was made upon medium 2.22 as in the previous cheese. The dilutions for the plates of this series were high in order to get a good development of the predominating organisms — the lactic germs. The second series of plates was made with medium 2.02 with the expectation of favoring the liquefiers at the expense of the acid-forming germs. The third series was made with medium 2.31. Few of the bacteria would develop on this medium on account of its high acidity while the yeasts thrived upon it fairly well. The dilutions for the second and third series were low, ranging from 1-200 to 1-5,000.

Qualitative flora.— Four examinations were made and 15 cultures isolated of which 12 are shown in Table V.

TABLE V.— GERMS FOUND IN CHEESE 4.6 III.

GROUP.	Type name (Conn).	AGE OF CHEESE IN DAYS.			
		2	7	14	45
Str. 212.22200	*Str. lacticus*	+	......	+	......
Bact. 212.22300	*Bact. lactis acidi D*	......	+	......	......
Bact. 212.33300	*Bact. lactis Connii*	+	......	......	......
M. 211.22200	*M. lactis albidus*	+	......	+ +	......
Bact. 221.22200	*Bact. lactis brevis*	+ +	......	......	......
Bact. 222.22200	*Bact. lactis acidi*	+	......	......	......
Str. 222.22200	*Str. lacticus*	......	+	......	......
M. 212.22205	*M. lactis aureus*	......	+	......	......

Of the forms present in this cheese Bacterium 222.22200 was also present in both of the former cheeses while Bact. 212.22300 and Bact. 221.22200 were found in Cheese 4.6 I.

Two strains of the type *Str. lacticus* were found in this cheese. These differ from the corresponding strains of *Bact. lactis acidi* only in morphology, and the latter are ordinarily so short that an exact separation of the forms into coccus and bacterium is difficult.

Quantitative results.— The quantitative results from the three media as well as the results of the physical examination are given in Table VI.

TABLE VI.—GERM CONTENT AND PHYSICAL CONDITION OF CHEESE 46 III.

Sample taken.	Age of cheese.	Germ s.	Liquefiers.	Yeasts.	Flavor.	Texture.	Body.	Color.	Score.
	Days.	*Per gram.*	*Per gram.*						
August 3	2	83,200,000	130,000	......	Slight acid. No bad flavor	Curdy........	Close, some mechanical holes...............	Wavy............	92
" 8	7	41,900,000	51,000	None...	....	....	....	....	.....
" 15	14	*.........	32,000	....	Traces of acid. Low, clean cheese flavor..........	Slightly stiff..	"	Slightly streaked..	93
Sept. 15	45	4,700,000	20,000	None...	Tainted, pungent........	Smooth, silky.	Close.................	Straight..........	94

* The results from this series of plates were very discordant, indicating some accident in their preparation.

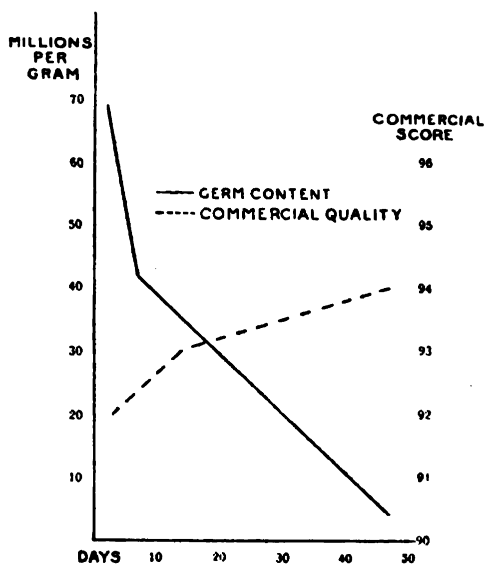
It will be noted that approximately 5,000,000 germs per gram were present in the fully ripened cheese. Liquefiers were also present in considerable numbers although they made up a relatively small part of the total flora.

A combination of the quantitative and qualitative results from the examinations of this cheese are given in Table VII.

TABLE VII.— BACTERIA OF GIVEN TYPE IN CHEESE 4.6 III.
(Per Gam of Cheese.)

Type name (Conn).	Group number.	2 days.	7 days.	14 days.	45 days.
Bact. lactis Connii.	Bact. 212.33300	1,000,000	....	......	....
Bact. lactis acidi D.	Bact. 212.22300	....	20,000	......	....
M. lactis aureus....	M. 212.22205	....	27,000	......	....
Bact. lactis brevis...	Bact. 222.22200	50,000	16,000	11,000	2,000
M. lactis albidus...	M. 211.22200	80,000	25,000	19,000	18,000
Bact. lactis acidi... *Bact. lactis acidi...* *Streptococcus lacticus.............*	Bact. 212.22200 Bact. 222.22200 Str. 212.22200	82,070,000	41,812,000	......	4,680,000
Total.......	....	83,200,000	41,900,000	......	4,700,000

Graphical representation.— During the 45 days in which this cheese was studied the germ content steadily decreased. At the



GRAPH III.— GERM CONTENT AND COMMERCIAL QUALITY OF CHEESE 4.6 III.

same time the commercial quality of the cheese was rapidly improving. The rate at which each of these changes occurred is shown in Graph III.

CHEESES 4.6 IV AND 4.6 V.

These cheeses were studied together for the purpose of bringing out the differences in the flora of good cheese made simultaneously at different factories.

They were made September 27, 1904, Cheese 4.6 IV at the Crown Brand factory, Denmark, N. Y., and Cheese 4.6 V at the Merry Factory, Verona, N. Y., and each reached our laboratory two days later. They weighed 48 and 33 lbs. respectively and were well made examples of home trade cheddar, their later scores showing them to be of unusually high quality.

After reaching us they were dipped in hot paraffin and placed in the curing room at 60° F. (15.5° C.). They were handled precisely alike, both in the curing room and in the time and manner of examination. The cheeses were studied until they were 92 days old, 9 samples being taken for analysis. The media used were similar to those used with Cheese 4.6 III.

Quantitative flora.— Twenty-seven cultures were isolated from Cheese 4.6 IV and 26 from Cheese 4.6 V. Twenty-six representative cultures from these two cheeses were classified upon cards as shown in Table VIII.

TABLE VIII.— GERMS FOUND IN CHEESES 4.6 IV AND 4.6 V.

Group number.	Type name (Conn).	4.6 IV.					4.6 V.				
		AGE IN DAYS.					AGE IN DAYS.				
		2	10	17	24	34	2	10	17	24	34
M. 211.22205	*M. lactis varians*							+			
M. 211.22206	*M. lactis giganteus*	+									
M. 211.33305	*M. lactis aureus A*		+								
Bact. 211.33310	*Bact. lactis album*						+				
Str. 212.22200	*Str. lacticus*			+							
M. 212.22205	*M. lactis aureus*							+			
Bact. 212.22300	*Bact. lactis acidi*				+						
M. 211.22200	*M. lactis albidus*						+				
M. 211.22215	*M. lactis varians*			+	+						
Bact. 221.22220	*Bact. lactis brevis*	+		+							
M. 211.22305	*M. lactis varians*	+									
Bact. 222.11100	*Bact. lactis aerogenes*					+					
Str. 222.22200	*Str. lacticus*			+ +							+
Bact. 222.22200	*Bact. lactis acidi*		+ +	+			+				+
Bact. 222.22300	*Bact. lactis acidi*	+									+ +
M. 212.22305	*M. lactis aureus*		+								

According to the above table the only germs common to both cheeses were Bact. 222.22200, Str. 222.22200 and Bact. 222.22300. As will be seen from Table XI, page 81, these forms really made up a very considerable part of the flora of each of these cheeses.

Quantitative results.— Plates were made upon media 2.22, 2.02 and 2.31 as explained under Cheese 4.6 III. The results of these examinations together with the commercial score and comments upon the physical condition of each cheese are given in Tables IX and X.

TABLE IX.—GERM CONTENT AND PHYSICAL CONDITION OF CHEESE 4.6 IV.

Sample taken.	Age of cheese.	Germs.	Liquefiers.	Yeasts.	Flavor.	Texture.	Body.	Color.	Score.
	Days.	*Per gram.*	*Per gram.*	*Per gm.*					
Sept. 29	2	6,500,700	54,000	......	Clean. Slightly acid.....	Curdy........	Close..................	Wavy............	91½
Oct. 7	10	37,100,000	31,900	1,200	Clean. Acid slight. Little cheese flavor.	"	"	Slightly wavy.....	94
" 14	17	14,100,000	6,800	220	Clean. Slight cheese flavor	Smooth......	Close. Waxy.........	"	95
" 21	24	13,700,000	6,900	260	Clean. Mild............	"	"	"	95½
" 31	34	3,000,000	7,800	46	Developing clean cheese flavor..............	Smooth, Silky	Close................	Straight..........	97
Nov. 7	41	5,900,000	2,900	33	Clean, fine flavor........	....	....	Perfect...........	98
" 15	49	*	....	......	Clean, fine flavor........	Smooth. Silky	Silky................	"	98½
" 21	55	3,600,000	7,100	680	Clean..................	....	....	"	98½
Dec. 82	92	1,100,000	....	......	Not as good............	....	....	....	97

* Plates melted and count lost.

TABLE X.—GERM CONTENT AND PHYSICAL CONDITION OF CHEESE 4.6 V.

Sample taken.	Age of cheese.	Germs.	Liquefiers.	Yeasts	Flavor.	Texture.	Body.	Color.	Score.
	Days.	*Per gram.*	*Per gram.*	*Per gm.*					
Sept. 29	2	90,600,000	11,700	......	Acid. Clean............	Stiff. Curdy..	Close..................	Slightly wavy.....	92
Oct. 7	10	54,200,000	2,000	3,200	Clean, acid. Faint cheese flavor.	Smooth......	"	Straight..........	94
" 14	17	33,300,000	5,500	......	Clean, faint acid. Little cheese flavor.	Smooth. Silky	"	Wavy...........	95
" 21	24	6,100,000	0	0	Faint bitter. Some cheese flavor.	"	"	Perfect..........	95½
" 31	34	31,200,000	300	40	Flavor developing. Not quite clean.	"	"	"	96½
Nov. 7	41	54,300,000	70	330	Slightly bitter..........	"	"	"	97
" 15	49	*	....	......		....	....	....	97½
" 21	55	2,500,000	500	60	Slightly bitter..........	"	"	"	97½
Dec. 28	92	7,300,000	....	......	Bad flavor has disappeared	....	....	....	98

* Plates melted and count lost.

A distinct difference in the quantitative flora of these two cheeses is evident. Cheese 4.6 IV is credited with but 6.5 millions per gram at 2 days. This is the average of the counts from 10 plates on medium 2.22 of which 7 were closely accordant while 3 gave markedly higher counts. This exceptionally low germ content may be connected with temperature conditions experienced in shipment or with variations in the method of manufacture of which nothing is known.

While the germ content of this cheese remained low during its entire history it ripened quickly and satisfactorily, receiving a score of 98½ at 49 days. The germ content at 41 days, when it was practically ripe from a commercial point of view, was about 6 millions per gram; and at 55 days there were still 3.5 millions germs per gram alive in the cheese. At 92 days when the cheese had passed its best and begun to deteriorate in commercial quality there were over 1 million germs per gram present.

Cheese 4. 6 V differed in that it had more than double the germ content found in Cheese 4.6 IV during practically the whole of the ripening period. However it ripened distinctly more slowly and did not attain its best until 92 days when it scored 98½. At this time it had a germ content of over 7 millions per gram. The apparently anomalous count at 24 days is based upon the results from 9 plates all of which were fairly accordant.

It will be observed that while the total germ content of the rapid-ripening Cheese 4.6 IV is uniformly low, it contained a considerable number of liquefying forms. On the contrary the slow ripening Cheese 4.6 V with its much larger total germ content contained few liquefiers.

The quantitative relations of the types present at each examination of the two cheeses are shown in Table XI.

This table makes it clear that representatives of the characteristic lactic-acid groups, *Str. lacticus* and *Bact. lactis acidi,* were only one-half to one-tenth as numerous in the rapid ripening Cheese 4.6 IV as in the slow ripening Cheese 4.6 V. After carefully considering these two cheeses it is hard to escape the conclusion that although the lactic group is of the first importance in the first stages of cheese ripening there are other more important factors controlling the rate of ripening during the later stages.

TABLE XI.— BACTERIA OF GIVEN TYPES IN CHEESES 4.6 IV AND V.
(Per Gram of Cheese.)

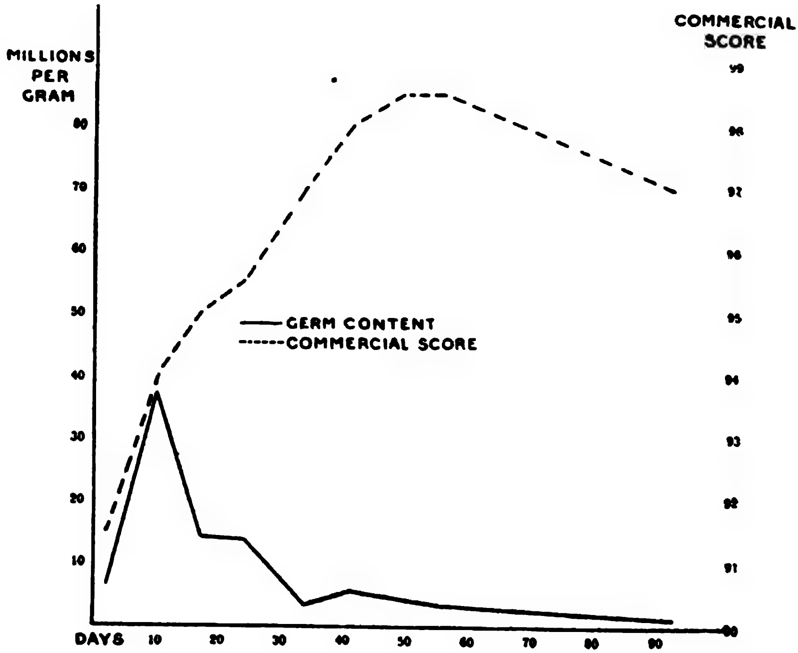
CHEESE 4.6 IV.

Type name (Conn).	Group number.	2 days.	10 days.	17 days	24 days.	34 days.	41 days.	55 days.	92 days.
M. lactis giganteus	M. 211.22206	850	....	....	....	....	....	....	....
M. lactis aureus	M. 212.22305	....	2,000	12,600	....	....	....	....	....
Bact. lactis aerogenes	Bact. 222.11100	....	5,000	....	....	....	....	....	....
M. lactis aureus A	M. 211.33305	....	22,300	5,000	4,000	....	....	2,100	....
Bact. lactis brevis	Bact. 222.22200	2,400	4,800	1,800	2,900	4,400	900	2,000	....
Bact. lactis brevis	Bact. 222.22220								
M. lactis varians	M. 211.22205	50,000	2,800	....	....	3,400	2,000	3,100	....
M. lactis varians	M. 211.22305								
Bact. lactis acidi	Bact. 212.22200								
Bact. lactis acidi	Bact. 212.22300								
Bact. lactis acidi	Bact. 222.22200	6,444,950	37,063,100	14,080,600	13,693,100	2,992,200	5,897,100	3,598,800	1,100,000
Streptococcus lacticus	Str. 212.22200								
Streptococcus lacticus	Str. 222.22200								
Total		6,500,000	37,100,000	14,100,0000	13,700,000	3,000,000	5,900,000	3,600,000	1,100,000

CHEESE 4.6 V.

Type name (Conn).	Group number.	2 days.	10 days.	17 days	24 days.	34 days.	41 days.	55 days.	92 days.
Bact. lactis album	Bact. 211.33310	7,000	....	....	....	....	....	....	....
M. lactis aureus	M. 212.22205	....	250	....	....	....	....	....	....
M. lactis varians	M. 211.22205	....	....	4,000	....	300	....	200	....
M. lactis albidus	M. 211.22200	4,700	2,000	1,500	....	....	70	300	....
Bact. lactis acidi	Bact. 222.22200								
Bact. lactis acidi	Bact. 222.22300	90,588,300	54,197,750	33,294,500	....	31,199,700	54,299,930	2,499,500	7,300,000
Streptococcus lacticus	Str. 222.22200								
Total		90,600,000	54,200,000	33,300,000	6,100,000	31,200,000	54,300,000	2,500,000	7,300,000

Graphical representation.— Graphs IV and V emphasize the fact that while Cheese 4.6 IV attained a higher commercial quality than Cheese 4.6 V, it did not long maintain this advantage. The markedly higher germ content of Cheese 4.6 V is also clearly shown. Cheese 4.6 IV was commercially ripe at 41 days while Cheese 4.6 V did not reach this condition until 92 days.



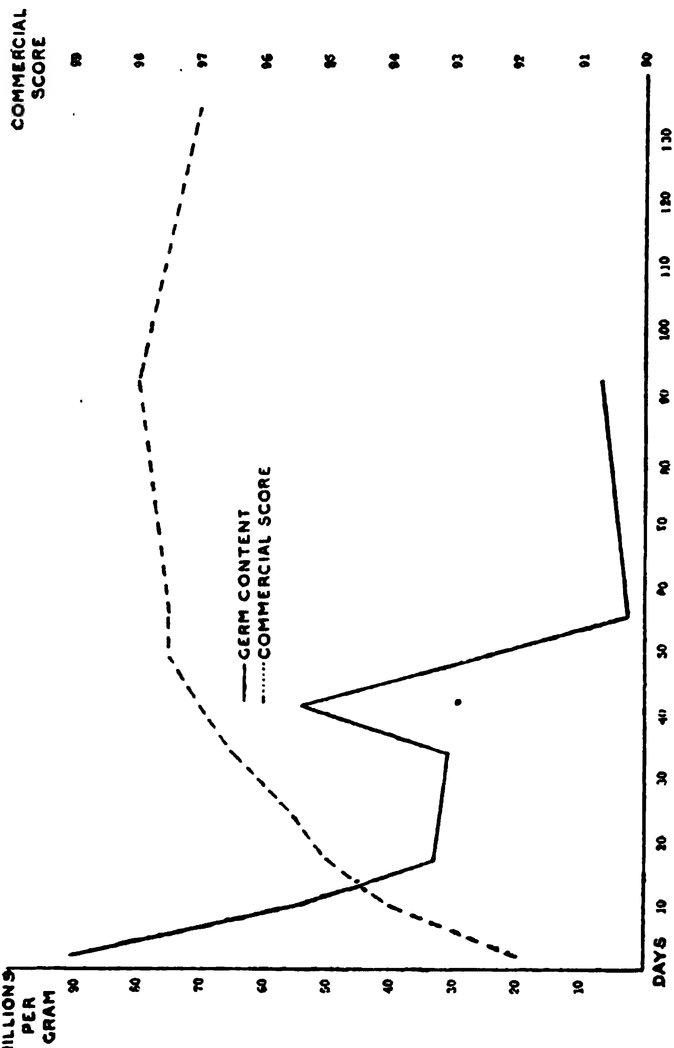
GRAPH IV.— GERM CONTENT AND COMMERCIAL QUALITY OF CHEESE 4.6 IV.

CHEESE 4.6 VII.

This 35-lb. home-trade cheese was made March 6, 1906, at Delevan, N. Y., and sent us by Mr. E. L. Jones. It was delayed in transit and did not reach us until March 13. It was at once dipped in hot paraffin and placed in the curing room at 60° F. (15.5° C.). Six samples were analyzed covering a period of 99 days.

Portions were plated each time upon media 2.02, 2.22 and 2.31 to determine the liquefiers, total germ content and yeasts respectively. At the first three examinations two additional series of plates were prepared with medium 2.22 and placed in Novy jars. In one series the oxygen was replaced with hydrogen and in the

other it was absorbed with pyrogalic acid and potassium hydroxide. In this way these studies were extended in a preliminary way to the anaerobic flora.



GRAPH V.—GERM CONTENT AND COMMERCIAL QUALITY OF CHEESE 4.6 V.

Qualitative results.— Twenty-five representative cultures were isolated and the type and time of isolation of 23 of them are shown in Table XII.

TABLE XII.— GERMS FOUND IN CHEESE 4.6 VII.

Group number.	Type name (Conn).	Age of cheese in days.			
		8	16	37	51
Bact. 212.22200	*Bact. lactis acidi*....................	......	+	......	......
Bact. 212.22300	*Bact. lactis acidi*....................	......	+	++	......
Bact. 212.33300	*Bact. lactis viscosum*..................	......	....	......	+++
M. 212.33305	*M. lactis citreus B*....................	......	....	+	......
M. 221.22205	*M. lactis varians*....................	......	++	+	+
Str. 222.22200	*Str. lacticus*....................	......	....	+	......
Bact. 222.22200	*Bact. lactis acidi*....................	+	++++	++	......
Bact. 222.22220	*Bact. lactis acidi*....................	+++	....	......	......

The type *M. lactis varians* was the only liquefier found in this cheese. A new type, *Bact. lactis viscosum,* was represented by three cultures isolated at 51 days. There is no apparent explanation for the appearance of this form in considerable numbers so late in the history of the cheese. The other types present have all been met with in previous cheeses.

Quantitative results.— The result from the plates made at 6 examinations on media 2.02, 2.22 and 2.31 as well as the commercial score and comments upon the physical condition of the cheese are given in Table XIII.

TABLE XIII.— GERM CONTENT AND PHYSICAL CONDITION OF CHEESE 4.6 VII.

Sample taken.	Age of cheese.	Germs.	Anaerobes.	Liquefiers.	Yeasts.	Flavor.	Texture.	Body.	Color.	Score.
		Per gram.	*Per gram.*	*Per gram.*	*Per gram.*					
Mar. 13	8	106,300,000	109,600,000	0	0	....	.. ..	....	....	......
" 21	16	74,100,000	70,800,000	45,000	100	Low with slight molasses flavor.........	Smooth....	Medium close.	Wavy..........	95½
Apr. 11	37	71,500,000	74,400,000	1,600	0	....	....	....	....	......
" 25	51	35,200,000	....	19,364	0	Clean..............	Smooth and silky.....	Close.........	Slightly wavy...	96
May 12	68	9,900,000	....	....	0	Tainted............	Smooth....	....	Slightly streaked	94
June 12	99	3,300,000	....	500	0	Tainted............	Smooth....	Salvy.......	....	95

This cheese was commercially ripe at 68 days and at that time had a germ content of over 9 millions per gram of cheese. The cheese was very well made but probably was exposed to unfavorable ripening temperature during the delay which occurred in transit. It had from the first a faint foreign flavor somewhat resembling molasses and as the cheese became fully ripened this taint was easily noticeable.

It will be seen that the numerical results obtained from the anaerobic plates were practically identical with those obtained upon the same medium with aerobic plates. The qualitative results were also identical in that no types of colonies were found on these anaerobic plates which were not also present on the aerobic ones. These results do not preclude the possibility of finding additional forms after continued work with this or other media. However it rendered the finding of such forms, in sufficient quantities to be of importance in the problem of cheese ripening, improbable and the work on this line was discontinued for the present.

The approximate number of each of the various forms present at the different examinations is given in Table XIV.

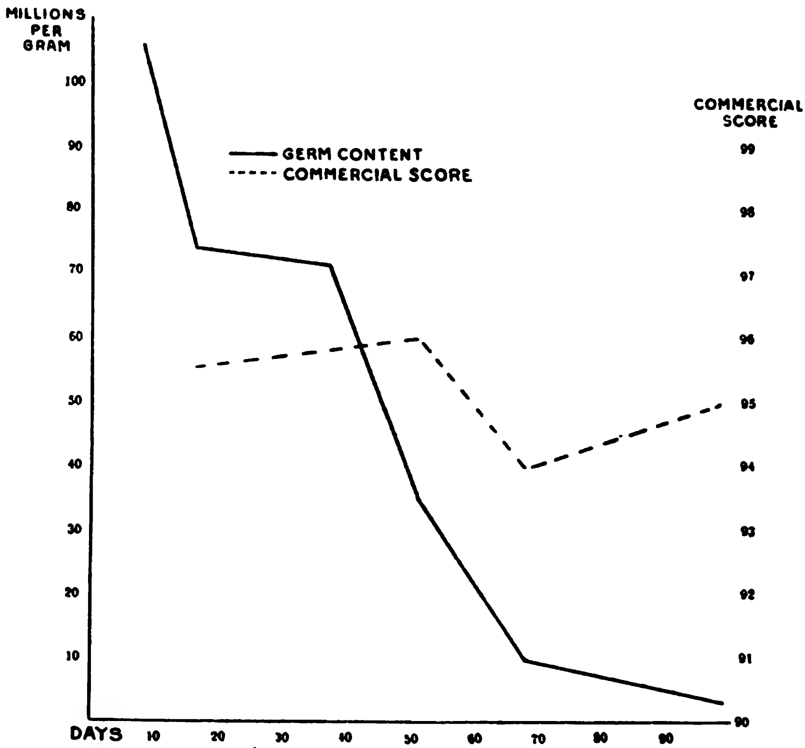
TABLE XIV.— BACTERIA OF GIVEN TYPES IN CHEESE 4.6 VII.

(Per Gram of Cheese.)

Type name (Conn).	Group number.	8	16	37	51	68	99
M. lactis citreus B	M. 212.33305	....	....	1,000	....	....	....
Bact. lactis viscosum	Bact. 212.33300	....	....	....	100,000	....	....
M. lactis varians	M. 221.22205	....	8,000	1,600	19,000	....	500
Bact. lactis acidi	Bact. 222.22200						
Bact. lactis acidi	Bact. 222.22220						
Bact. lactis acidi	Bact. 212.22200	106,300,000	74,092,000	35,497,400	35,200,000	9,900,000	3,299,500
Bact. lactis acidi	Bact. 212.22300						
Streptococcus lacticus	Str. 222.22200						
Total	....	106,300,000	74,100,000	71,500,000	35,200,000	9,900,000	3,300,000

From this table we see that, aside from *M. lactis varians,* the germ content was almost exclusively composed of the typical lactic germs. Since it required 68 days to ripen, the presence of an unusually large number of the lactic organisms during the entire period did not appear to hasten the ripening processes of the cheese.

Graphical representation.— Graph VI shows at a glance that the germ content of this cheese during its 68 day ripening period was greater by many thousands per gram than those previously studied. The irregularity in the commercial score is due to the development of an objectionable taint.



GRAPH VI.— GERM CONTENT AND COMMERCIAL QUALITY OF CHEESE 4.6 VII.

CHEESE 4.6 VIII.

Up to this point all of the cheeses studied were from 2 to 8 days old before the first sample was taken for analysis. With

Cheese 4.6 VIII, which was made June 18, 1906, by our Dairy Expert in our own dairy, examinations were begun with the milk in the vat. Sixteen samples were taken representing the milk, whey, curd and the ripening cheese. These extended over a period of 62 days.

On the second day the cheese was dipped in hot paraffin and placed in the curing room at 60° F. (15.5° C.).

This cheese differed markedly from those previously tested as they were good examples of home-trade cheddar cheese while this was of the dryer, export type and ripened correspondingly slower. The cheese developed a fairly clean mild flavor but was not fully ripened at 62 days.

The milk used was that from our own herd and, as we were then testing a milking machine without keeping the rubber parts in brine, the milk had an undesirable flora. Notwithstanding the addition of a liberal starter, slight evidence of gas formation appeared early in the process of manufacture but did not become troublesome.

In making cheese in small quantities it is difficult to avoid eliminating too much moisture and accordingly the cheese was dryer than was intended.

Qualitative results.— The distribution of the 14 cultures which were selected as representative of those present is shown in Table XV.

TABLE XV.— GERMS FOUND IN CHEESE 4.6 VIII.

Group number.	Type name (Conn).	Age of cheese.						
		Milk.	Whey.	2 days.	4 days.	10 days.	29 days.	36 days.
B. 111.33305	*B. lactis chromatum*			+				
Bact. 112.33305	*Bact. lactis aureum II*			+				
M. 211.33300	*M. lactis albus*	+			+			
Bact. 211.33300	*Bact. lactis album*					+		
Bact. 212.22200	*Bact. lactis acidi C.*	+						
M. 212.22200	*M. lactis acidi*	+						
Bact. 212.22300	*Bact. lactis acidi*						+	
Bact. 212.33300	*Bact. lactis Connii*	+						+
Bact. 212.33307		+						
Bact. 222.11100	*Bact. lactis aerogenes*		+				+	
B. 222.11100	*B. coli aerogenes*	+						

The dairy in which this cheese was made is seldom used for cheese making and it was to be expected that the flora of this cheese would be somewhat abnormal. Only four of the organisms present have been met with in the other cheeses. Bact. 212.22200 and Bact. 212.22300 are familiar lactic forms and were present in con-

siderable numbers while Bact. 212.33300 was found in Cheese 4.6 III. The latter is probably not an active form in connection with cheese-ripening processes as it neither attacks sugar nor produces digesting enzyms. Bact. 222.11100 was also isolated from Cheese 4.6 IV. It is not considered active in the ripening of cheese because it is never found in any considerable quantities in a first-class article. It is a vigorous gas former, is not found in clean milk and is inhibited by the cheese-making process.

Soon after the milk was put into the vat signs of gas production began to manifest themselves but were soon suppressed and the resulting curd was free from gas holes. Coincident with gas production two species of gas-producing bacteria were found in the milk and cheese. *B. coli aerogenes,* B. 222.11100, was found in the first sample only and in very small numbers. *Bact. lactis aerogenes,* Bact. 222.11100, made up about 10 per ct. of the flora of the first three samples.

The results from this cheese accord with the idea that aside from the lactic group there is no single group or at least no single species of bacteria absolutely essential to the ripening process. It must be admitted, however, that the ripening of Cheese 4.6 VIII was neither so rapid nor so satisfactory as might be desired.

Quantitative results.— Plates were made upon media 2.22, 2.02 and 2.31 for the purpose of determining the total flora, the liquefiers and the yeasts respectively. The results of these examinations are given in Table XVI.

TABLE XVI.—GERM CONTENT OF CHEESE 4.6 VIII.

Sample taken.	Age of cheese.	Total germ content.	Liquefiers.	Yeasts.	Lactic bacteria.	Gas producers.	Indifferent.
		Per cc.	*Per cc.*	*Per cc.*	*Per cc.*	*Per cc.*	*Per cc.*
June 18, 8.30 A. M.	Milk	9,000,000	8,000	....	4,372,000	1,010,000	3,610,000
" 18, 9.30 A. M.	"	16,200,000	10,000	200	11,770,000	1,620,000	2,800,000
" 18, 11.30 A. M.	Whey	10,000,000	3,000	0	7,500,000	1,000,000	1,500,000
		Per gram.	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*
June 18, 3.00 P. M.	Curd in vat	3,000,000	500	0	2,999,500	....	....
" 18, 4.30 P. M.	Curd in vat	14,100,000	1,000	0	14,051,000	....	....
" 18, 8.00 P. M.	3 hours in press	1,800,000	300	0	1,799,700	....	....
" 19	1 day	26,800,000	5,000	0	25,670,000	324,000	....
" 20	2 "	9,000,000	5,000	0	8,997,000	....	....
" 22	4 "	3,000,000	3,000	0	2,997,000	....	....
" 28	10 "	1,600,000	3,500	50	1,596,500	....	....
July 5	17 "	720,000	0	0	720,000	....	....
" 11	23 "	1,900,000	0	0	1,806,000	94,000	....
Aug. 2	45 "	750,000	2,400	0	731,600	....	16,000
" 10	53 "	1,000,000	....	0	1,000,000	....	....
Sept. 19	99 "	1,000,000	....	0	1,000,000	....	....

In attempting to express the changes which take place in the flora as the process of manufacture proceeds there is difficulty in choosing proper units of measurement. Cubic centimeter and gram are the units universally used in work with milk and cheese respectively but when used together in a single study they do not express equivalent amounts. As similar observations have been made upon the germ content of the milk, whey and curd in the case of a number of cheeses a discussion of this phase of the question will be deferred until data from two more cheeses have been presented.

No result from the commercial examination is given for this cheese partly because of the necessary absence of Mr. Smith at the dates of many of the analyses and partly because of the inherent difficulty of his giving an impartial judgment concerning his own product. The ripening progressed satisfactorily though slowly, as is to be expected with this type of cheese.

It is seen that while the germ content of the milk at the time that the rennet was added was 16 millions per cc. that of the whey 2 hours later was only 10 millions per cc. This would suggest that through the coagulation produced by the rennet a considerable proportion of the germs were caught and held in the curd. Turning to the observations on the curd it is seen that during the time that the curd in the vat was undergoing the so-called ripening process the bacteria multiplied from less than 3 millions to over 14 millions per gram. More surprising is the observation that after being put to press the germ content fell again in 3½ hours to less than 2 millions per gram. On the following day it contained 26 millions but from this point the germ content decreased at first rapidly and then more slowly. At 99 days there were still 1 million living germs per gram in the cheese.

This cheese was conspicuous for its low germ content, the bacteria present being pre-eminently of the lactic type. Yeasts were found in only two samples and then in small numbers. Liquefiers, though present, were not numerous and many plates did not show any.

The number of organisms of each type present at each examination as estimated from the colonies on the plates is given in Table XVII.

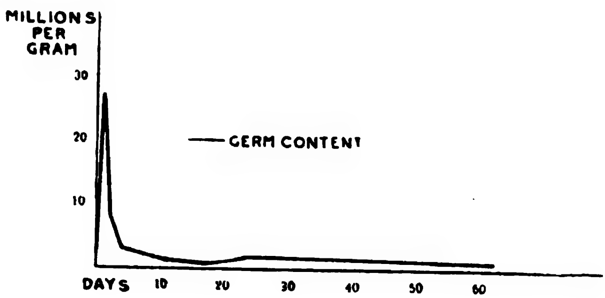
TABLE XVII.— BACTERIA OF GIVEN TYPES IN CHEESE 4.6 VIII.

No.	Type name (Conn).	Group number.		AGE OF CHEESE.				
				Milk.	Milk-ripe.	Whey.	Curd.	Curd.
				Per cc.	*Per cc.*	*Per cc.*	*Per gram.*	*Per gram.*
1	*B. coli aerogenes*	B.	222.11100	10,000	....	....	....	....
2	....	Bac.	212.33307	10,000	....	....	....	....
3	*Bact. lactis aureum II*	Bact.	112.33305	....	....	....	....	48,000
4	*B. lactis chromatum*	B.	111.33305	....	2,000	....	....	....
5	*Bact. lactis Connii*	Bact.	212.33300	3,600,000	2,800,000	1,500,000	....	....
6	*Bact. lactis aerogenes*	Bact.	222.11100	1,000,000	1,620,000	1,000,000	....	....
7	*Bact. lactis album*	Bact.	211.33300	3,000	4,000	....	....	1,000
8	*M. lactis albus*	M.	211.33300	5,000	6,000	3,000	500	....
	Bact. lactis acidi	Bact.	212.22300					
9	*Bact. lactis acidi C*	Bact.	212.22200	4,372,000	11,770,000	7,500,000	2,999,500	14,051,000
	M. lactis acidi	M.	212.22200					
	Total	....		9,000,000	16,200,000	10,000,000	3,000,000	14,000,000

Number.	AGE OF CHEESE.									
	3 hours in press.	1 day.	2 days.	4 days.	10 days.	17 days.	23 days.	45 days.	53 days.	99 days.
	Per gram.	*Per gram.*	*Per gram.*	*Per gram*	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*
1	....	....	....	....	....	....	....	....	....	....
2	....	....	....	....	....	....	....	....	....	....
3	....	....	1,000	....	....	....	....	....	....	....
4	....	....	2,000	....	....	....	....	....	....	....
5	....	....	....	....	....	....	....	16,000	....	....
6	....	324,000	....	....	....	....	94,000	....	....	....
7	....	....	600	....	1,500	....	....	1,000	....	....
8	300	5,000	3,000	3,000	2,000	....	....	1,400	....	....
9	1,799,700	25,670,000	8,996,400	2,997,000	1,596,500	720,000	1,806,000	731,000	1,000,000	1,000,000
Total	1,800,000	26,800,000	9,000,000	3,000,000	1,600,000	720,000	1,900,000	750,000	1,000,000	1,000,000

This table brings out the fact that the lactic forms are the only ones which persisted steadily and in large numbers throughout the ripening period of the cheese. The other forms which were recognized at intervals were relatively so scarce as to be often missed on account of the dilutions employed. The recognition of the acid forms was made easy by the presence of litmus in the media, but the separation of the non-acid forms was a matter of judgment assisted by the isolation of type colonies in some cases.

Graphical representation.— Graph VII shows the changes in the germ content of Cheese 4.6 VIII and brings out clearly the relatively small numbers present. In this particular it is in strong contrast to Cheese 4.6 VII.



GRAPH VII.— GERM CONTENT OF CHEESE 4.6 VIII.

CHEESE 4.6 IX.

We now attempted to carry out upon a normal cheese observations regarding the changes in the flora on the first two days similar to those which had been made on Cheese 4.6 VIII. Through the kindness of Mr. G. Merry the work was done at his factory at Verona, N. Y., on June 23, 1906.

The samples of milk, whey and curd were obtained from a large vat of milk undergoing the normal process of manufacture of home-trade cheddar. One of the cheeses produced from this vat, after being in the press only a few hours, was brought to our own dairy and there pressed until the following day. It was then dipped in hot paraffin and placed in our curing room at 60° F. (15.5° C.).

Fourteen samples were analyzed, covering a period of 98 days. The cheese at the end of that time was of good flavor but somewhat over-ripened.

Qualitative results.— Ten representative cultures were selected and classified on the cards as shown in Table XVIII.

TABLE XVIII.— GERMS FOUND IN CHEESE 4.6 IX.

Group number.		Type name (Conn).	Age of cheese in days.				
			Milk.	Whey.	Curd.	4 days.	38 days.
M.	211.22200	*M. lactis albidus*	+	+	......	......	......
S.	212.22200	*Str. lacticus*	......	+	......	......	......
M.	212.33300	*Galactococcus versicolor*	+	......	......	......	......
M.	212.33305	*M. lactis citreus B*	......	......	......	+	......
Bact.	221.22200	*Bact. lactis brevis*	......	......	+	......	......
Bact.	222.11100	*Bact. lactis aerogenes*	+	......	......	......	......
Bact.	222.22200	*Bact. lactis acidi*	+	+	......	......	......
Bact.	222.22300	*Bact. lactis acidi*	......	......	......	......	+

Quantitative results.— The total germ content was taken from plates upon medium 2.22 and this count was subdivided into the typical acid type and the inert organisms. The liquefiers were determined on medium 2.02 and plates were made with medium 2.31 for yeasts but with a single exception none were found. This failure to appear on these plates was probably not due to the use of excessive amounts of acid since in a number of instances bacterial colonies in considerable numbers developed on these plates. A summary of these observations is given in Table XIX.

TABLE XIX.—GERM CONTENT OF CHEESE 4.6 IX.

Sample taken.	Age of cheese.	Total germ content.	Liquefiers.	Yeasts.	Lactic acid bacteria.	Gas producers.	Inert.
		Per cc.	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
June 23	Milk, 9 A. M.	9,820,000	7,820,000	....	1,145,800	93,700	140,500
June 23	Milk, 10.10 A. M.	28,800,000	11,520,000	....	16,358,400	576,000	345,600
June 23	Whey, 12.15 P. M.	33,600,000	4,040,000	....	27,410,000	1,344,000	806,400
		Per gram.	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*
June 23	Curd, 1.45 P. M.	4,100,000	250,000	2,500	3,496,000	80,000	274,000
June 23	Curd, 3.30 P. M.	19,400,000	155,000	0	19,225,600	19,400	....
June 24	1 day	6,900,000	34,000	0	6,838,500	27,500	....
June 27	4 days	7,200,000	21,700	0	7,163,900	14,400	....
July 11	18 days	12,900,000	5,000	0	12,772,100	123,900	....
July 18	25 days	51,400,000	21,000	0	50,979,000	....	....
July 25	32 days	6,200,000	8,300	0	6,200,000	....	....
August 10	48 days	6,900,000	....	0	6,900,000	....	....
September 19	88 days	1,300,000	....	0	1,300,000	....	....

The early changes in the flora as noted here are similar to those found in Cheese 4.6 VIII. The first sample was taken from the mixed milk as furnished by the farmers and showed over 9 millions per cc. Owing to the ripeness of the milk no starter was added. The second sample was taken after the milk had been gradually warmed to 86° F. (30° C.) and the Marschall test set at 4 spaces. This warming had so stimulated growth that there were nearly 29 millions of germs per cc. Two hours later when the curd had been cut, the temperature raised to 100° F. (38° C.), the whey expelled and a large amount of acid developed, the whey contained 33 millions per cc. In this case the growth which had taken place in the whey had more than replaced the number which had been held back in the curd by the coagulation of the milk. As the volume of the whey is nine-tenths that of the original milk the number of germs removed with it is exceedingly great.

No scales being then at hand the two samples of curd taken at the factory were not weighed but estimated. This estimate was probably accurate within 25 per ct. The first sample of curd was taken shortly after the last of the whey had been removed and showed 4 millions per gram. The second sample, taken as the curd was being put to press had 19 millions per gram. The weighed sample taken at our laboratory when the cheese was 1 day old showed 7 millions per gram. This rapid shift in the numbers would create a suspicion that estimate of the weight of the curd sample was very inaccurate but for the fact that the changes here recorded in the germ content are in accord with those observed in Cheese 4.6 VIII.

This cheese was unusual in that the maximum count of 50 millions per gram was on the 23d day, the count meanwhile showing a steady increase from the low count at 1 day. After 23 days the count steadily decreased until at 88 days it was only 1.3 millions per gram. At this time the cheese was over-ripened.

The liquefiers were unusually abundant in the milk at both examinations but by the time the cheese went to press they constituted less than 1 per ct. of the total flora. Yeasts were not found except in one sample of the curd in the vat.

The numbers of the various types of organisms found at each examination is given in Table XX.

For some days preceding the making of this cheese gas formation in the vats had been of daily occurrence. In this cheese, while

TABLE XX.—BACTERIA OF GIVEN TYPES IN CHEESE 4.6 IX.

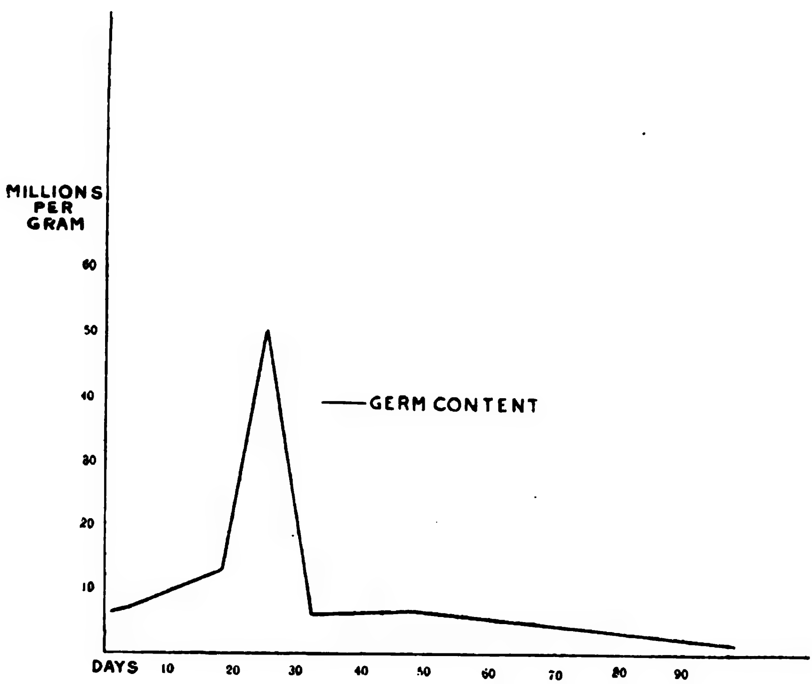
No.	Type name (Conn).	Group number.		AGE OF MATERIAL. Milk.	Milk-ripe.	Whey.	Curd in vat.	Curd in press 2 hours.
				Per cc.	*Per cc.*	*Per cc.*	*Per gram.*	*Per gram.*
1	*M. lactis varians*	M.	221.22205	140,000	86,400	201,000	24,000	....
2	*M. lactis citreus B*	M.	212.33305	46,900	144,000	336,000	32,000	38,000
3	*Bact. lactis acidi*	Bact.	222.22300	187,000	576,000	1,000,000	80,000	194,000
4	*Galactococcus versicolor*	Str.	212.33300	93,700	201,000	470,000	40,000	776,000
5	*Bact. lactis aerogenes*	Bact.	222.11100	93,000	576,000	1,300,000	80,000	19,400
6	*Bact. lactis brevis*	Bact.	227.22200	90,000	432,000	336,000	24,000	38,000
7	*M. lactis albidus*	M.	211.22200	7,590,000	11,001,600	3,503,000	207,000	117,000
8	*Streptococcus lacticus*	Str.	212.22200	281,000	1,400,000	2,300,000	300,000	1,940,000
9	*Bact. lactis acidi*	Bact.	222.22200	864,800	14,958,400	25,110,000	3,196,000	17,285,600
10	Total			9,200,000	28,800,000	33,600,000	4,100,000	19,400,000

Number.	AGE OF CHEESE. 1 day.	4 days.	18 days.	25 days.	32 days.	48 days.	88 days.
	Per gram.	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*
1	....	....	....	....	....	....	....
2	....	14,000	....	....	....	....	....
3	6,900	7,200	....	....	....	....	....
4	206,000	87,000	24,000	....	....	....	....
5	27,000	14,000	123,000	....	....	....	....
6	....	....	....	5,000	....	....	....
7	34,000	21,700	5,000	16,000	8,300	....	....
8	830,000	720,000	1,289,000	4,570,000	616,000	690,000	126,000
9	6,008,500	6,443,900	11,483,100	46,909,000	5,584,000	5,210,000	1,174,000
10	6,900,000	7,200,000	12,900,000	51,400,000	6,200,000	6,900,000	1,300,000

but few gas holes appeared, the formation of acid was considerably retarded. *Bact. lactis aerogenes* was the only gas-forming organism isolated. This form was abundant in the milk and whey but did not thrive in the curd and cheese.

Liquefiers, especially *M. lactis albidus,* were unusually abundant in the milk, making up the larger part of the germ content at the first sample. They were rapidly surpassed by the lactic forms and did not appear to increase in the curd or the cheese. After 25 days all of the germs found were representatives of the lactic group. Unfortunately we did not obtain the commercial score of this cheese but it ripened fairly slowly. There is no evidence that the large number of *M. lactis albidus* present in the milk hastened the ripening of the cheese.

Graphical representation.— Graph VIII shows the changes which were noted in the germ content of Cheese 4.6 IX between the first and the 89th day. This cheese is unusual in that it had a large germ content on the 25th day.



GRAPH VIII.— GERM CONTENT OF CHEESE 4.6 IX.

This cheese was studied with a view to repeating the observations on the early changes in the flora and was made by Mr. Smith from the milk of our own herd on July 9, 1906. The milk was not of the first quality for the same reasons given under Cheese 4.6 VIII and some evidence of gas formation appeared early but did not become sufficiently pronounced to show in the curd. For the reasons already explained the resulting cheese was of the export rather than the home-trade type, and while it cured satisfactorily did not attain its best physical texture until at the end of 8 months.

The cheese was dipped in paraffin when taken from the press and was cured at 60° F. (15.5° C.). Sixteen samples were taken covering a period of 72 days.

Qualitative results.— Eighteen cultures were isolated as representative of the flora and the results of their classification on the card is shown in Table XXI.

TABLE XXI.— GERMS FOUND IN CHEESE 4.6 X.

Group number.	Type Name (Conn.)	AGE OF CHEESE IN DAYS.								
		Milk.	Whey.	Curd.	1	4	7	12	19	28
M. 211.23200	*M. lactis albidus*	+	.....	.....	..	..	..	..	.....	..
Str. 212.22200	*Streptococcus lacticus*	.....	.....	+	..	..	..	..	+	..
M. 221.22200	*M. lactis albidus*	.....	.....	+	+	..	..	..	.....	..
Bact. 212.33300	*Bact. lactis viscosum*	++	+	.....	..	..	..	..	.....	..
Bact. 222.11100	*Bact. lactis aerogenes*	++	++	.....	..	..	..	..	.....	..
Bact. 222.22200	*Bact. lactis acidi*	.....	.....	+	..	..	..	+	+++	..
B. 222.11100	*B. coli aerogenes*	+	.....	.....	..	..	..	..	.....	..

All of the germs found in this cheese had been found in some of the previous cheeses.

Quantitative results.— The total germ content was obtained from plates upon medium 2.22. The division into the lactic acid, gas-producing and inert group was made upon this medium. The liquefiers were determined on medium 2.02 and the yeasts on 2.31. The results from these observations are given in Table XXII.

TABLE XXII.—GERM CONTENT OF CHEESE 4.6 X.

Sample taken.	Age of cheese.	Total germ content.	Liquefiers.	Yeasts.	Lactic acid bacteria.	Gas producers.	Inert.
		Per cc.	*Per cc.*		*Per cc.*	*Per cc.*	*Per cc.*
July 9	Milk, 9 A. M.	46,800,000	....	0	33,660,000	6,740,000	6,400,000
July 9	Whey, 10.30 A. M.	23,100,000	17,000	0	20,587,000	1,772,000	724,000
July 9	Whey, 12 M.	42,900,000	15,000	0	34,691,000	6,364,000	1,830,000
		Per gram.	*Per gram.*		*Per gram.*	*Per gram.*	*Per gram.*
July 9	Curd, 2.00 P. M.	16,400,000	14,000	0	12,695,000	401,000	100,000
July 9	Curd, 4.00 P. M.	94,500,000	20,000	0	94,480,000	....	....
July 9	5 hours in press	26,600,000	....	0	26,580,000	....	20,000
July 9	8 hours in press	102,300,000	5,500	0	102,294,500	....	....
July 10	19 hours in press	177,900,000	2,000	0	177,878,000	20,000	....
July 10	1 day	35,100,000	4,000	0	35,087,000	9,000	....
July 13	4 days	29,300,000	....	0	29,300,000	....	....
July 16	7 days	46,100,000	2,000	0	46,098,000	....	....
July 21	12 days	25,500,000	3,000	0	25,473,000	24,000	....
July 28	19 days	1,800,000	1,000	0	1,799,000	....	....

The milk for this cheese when mixed in the vat contained over 46 million germs per cc. Seventy-two per ct. were lactic acid, 15 per ct. gas producers and 13 per ct. were inert forms. The liquefiers were very scarce in all of the samples. No yeasts developed on any of the plates.

Immediately after coagulation of the milk the whey contained only 23 million germs per cc. but when the whey was drawn, ninety minutes later, the germ content had increased to 43 millions per cc. The curd in the vat at 2 p. m. contained 16 millions per gram and two hours later, after being salted and laying one hour in press the number had increased to 94 millions per gram. Five hours later the number of germs was determined at 26 millions and plates made after a further interval of two hours showed 105 millions per gram. The maximum germ content of 178 millions per gram was obtained after the cheese had been 19 hours in press.

The wide and rapid variations observed in the germ content of the whey and the curd deserve an explanation. While the preparation of a correct sample of the fresh curd is difficult it is easy to get a representative one in the case of the whey; yet the fluctuation in germ content is almost equally pronounced in both. While our data are restricted to preliminary observations on three cheeses the fluctuations in germ content seem to stand in a general relation to the stages of manufacture. On this account we are inclined to the belief that these variations in our results are not due to faulty technique, as we at first supposed, but are due to changes in temperature and in physical and chemical environment during the process of manufacture.

The numbers of the various types of germs found at each examination are given in Table XXIII.

All of these types of germs have been found in one or more of the previous cheeses. This cheese is conspicuous in the absence of any other than the lactic acid type of germs after the curd was put to press.

Graphical representation.— Graph IX (page 105) brings out the extremely high germ content during the first day. The decrease in the germ content was unusually rapid so that after 19 days the number present was very much below the average of the cheeses studied.

TABLE XXIII.— BACTERIA OF GIVEN TYPES IN CHEESE 4.6 X.

No.	Type name (Conn).	Group number.		AGE OF MATERIAL.				
				Milk. 9.00 A. M.	Whey 10.30 A.M.	Whey 12 P.M.	Curd 2.00 P.M.	Curd 4.00 P.M.
				Per cc.	*Per cc.*	*Per cc.*	*Per gram.*	*Per gram.*
1	*B. coli aerogenes*	B.	222.11100	340,000	32,000	24,000	1,000	....
2	*Bact. lactis viscosum*	Bact.	212.33300	6,400,000	724,000	1,830,000	100,000	....
3	*M. lactis albidus C*	M.	211.23200	....	....	....	....	1,000
4	*Bact. lactis aerogenes*	Bact.	222.11100	6,400,000	1,740,000	6,340,000	400,000	....
5	*M. lactis albidus*	M.	221.22200	....	17,000	15,000	14,000	20,000
6	*Streptococcus lacticus*	Str.	212.22200	1,000,000	500,000	1,000,000	3,190,000	4,000,000
7	*Bact. lactis acidi*	Bact.	222.22200	32,660,000	20,087,000	33,691,000	12,695,000	90,479,000
8	Totals	....		46,800,000	23,100,000	42,900,000	16,400,000	94,500,000

Number.	AGE OF CHEESE.							
	5 hours in press.	8 hours in press.	19 hours in press.	1 day.	4 days.	7 days.	12 days.	19 days.
	Per gram.	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*	*Per gram.*
1	....	....	....	....	....	....	....	....
2	20,000	....	....	....	....	....	....	....
3	....	....	....	....	....	....	....	....
4	....	....	20,000	9,000	....	....	24,000	....
5	....	5,500	2,000	4,000	....	2,000	3,000	1,000
6	2,000,000	6,000,000	7,000,000	3,000,000	2,500,000	2,000,000	2,000,000	....
7	24,580,000	96,294,500	170,878,000	32,087,000	26,800,000	44,098,000	23,473,000	1,799,000
8	26,600,000	102,300,000	177,900,000	35,100,000	29,300,000	46,100,000	25,500,000	1,800,000

COMBINED FLORA OF THE NINE CHEESES.

QUANTITATIVE SUMMARY.

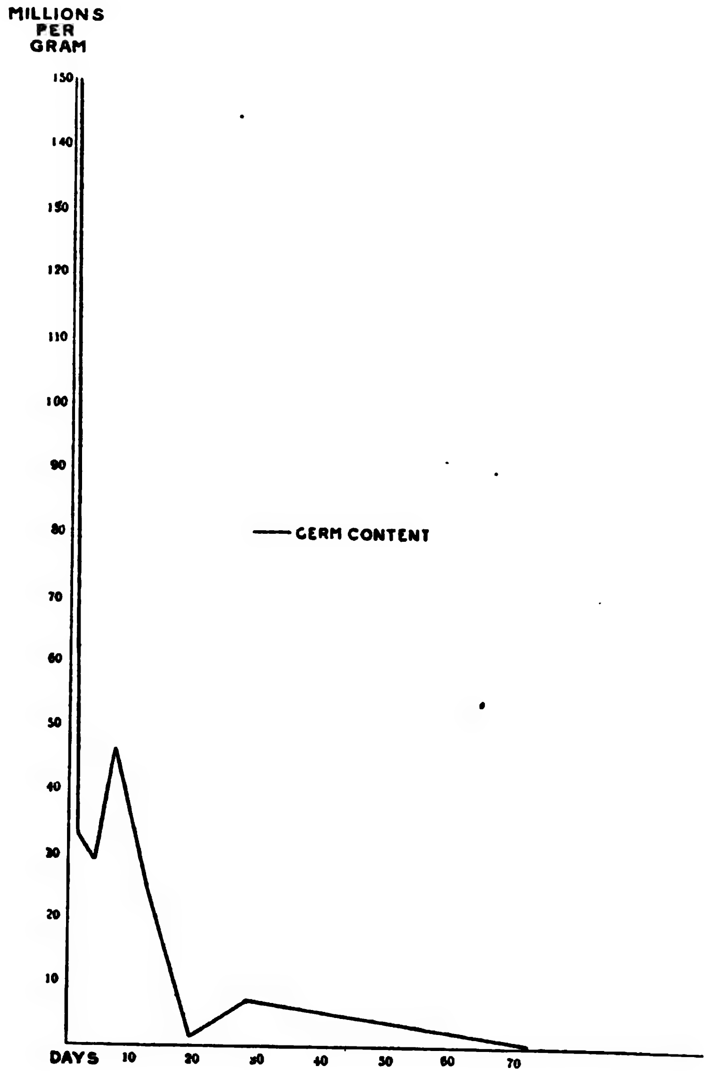
For the reasons already given quantitative results on the germ content of the milk and whey are available for only three cheeses, the study of the germ content of the other cheeses beginning after two to eight days.

At the time of beginning the process of manufacture the germ content of the milk for Cheeses 4.6 VIII, IX and X was 9, 9, and 47 millions per cc. respectively. From the time the milk is put into the vat until the cheese is ready for the press a temperature favorable to germ life is maintained. During the first hour the germ content rose in the milk for Cheese 4.6 VIII to 16 millions and in that for IX to 29 millions per cc.

The addition of rennet separates the milk into whey and curd. In Cheese 4.6 VIII while the milk contained 16 millions per cc. when the rennet was added, the whey showed only 10 millions per cc. after the lapse of two hours. In Cheese 4.6 IX two hours after adding the rennet the germ content of the whey was 5 millions per cc. higher than that observed in the milk. In Cheese 4.6 X when the curd was first cut the whey contained 26 millions per cc. less tnan were found in the milk one and one-half hour previous. Within the following hour and a half the whey increased 20 millions per cc. leaving it only 4 millions lower in germ content than the original milk. It would seem a fair deduction from these data that in the process of coagulation a large proportion of the germs in the milk are caught in the curd, but that the favorable growth conditions in the whey leads to a rapid multiplication in that fluid.

In studying the flora of the curd the gram is taken as the unit of measurement. At first the specific gravity of the curd does not differ markedly from that of the whey but with the continued expulsion of the moisture it increases to about 1.5. Exact data on these changes are lacking. In order to make comparisons of the quantitative results in milk, whey and curd, the numbers per gram found in the curd should be multiplied by a factor not larger than one and one-half. Our data indicate that as the whey is expelled from the coagulated mass it does not contain its volumetric proportion of the germs previously found in the milk. Unfortunately we have no observations on the germ content of the freshly coagulated curd but observations made upon the ripened curd just previous to adding

the salt indicated that it then had a smaller germ content than an equal volume of the milk from which it was made. This apparent



Graph IX.— Germ Content of Cheese 46 X.

decrease in the germ life in both the whey and the curd in the presence of what are believed to be highly favorable conditions

for its development awaits a satisfactory explanation. There is also evidence for the belief that the salt applied at the next step in the process of manufacture markedly reduces the germ content of the curd. Whether it acts as a germicide or mechanically, by removing the germs along with the moisture which leaves the curd by osmosis, is not determined. The mechanical difficulties of a bacterial analysis of the fresh curd are great and some of the observed variations may be attributed to this cause. This portion of the cheese-making process deserves a more extended study than it has yet received.

In different cheeses the rate of increase, the maximum germ content and the age at which it is attained, as well as the rate of decline after this point, vary greatly. The causes of these variations are only partly understood. Harrison and Connell[24] have shown that the temperature has an important influence, the work of Marshall[25] places emphasis on the associative action of the different members of the flora, while current belief among the cheese makers lays great stress upon the moisture content. All of the cheeses except Cheese 4.6 II were cured at 60° F. (15.5° C.) but with the exception of Cheeses 4.6 VIII, IX and X the forms which were present in the milk are unknown and the moisture content was not determined.

In Cheeses 4.6 I to VII the first sample was taken when the cheese arrived at an age varying from two to eight days. In five of these six samples the germ content was the highest recorded for the particular cheese. However it is improbable that this really was the maximum content attained in each case since two of the three cheeses which were studied during their manufacture attained their maximum within the first twenty-four hours.

The maximum recorded germ content for each cheese with the age at which it was observed is given in Table XXIV.

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[24] Harrison, F. C. and Connell, W. T. A comparison of the bacterial content of cheese cured at different temperatures. *Rev. gen. du Lait*, 3: 80–85, 103–111, 126–137, 150–155, 173–180. 1904.

[25] Marshall, C. E. A preliminary note on the associative action of bacteria in the souring of milk. *Cent. Bakt.*, II Abt., 11: 739–744. 1903. Also, Additional work upon the associative action of bacteria in the souring of milk. *Cent. Bakt.*, II Abt., 12: 593–597. 1904.

TABLE XXIV.—MAXIMUM OBSERVED GERM CONTENT IN CHEESES.

NUMBER OF CHEESE.	Age of cheese.	Bacteria per gram.
	Days.	
4.6 I	4	135,706,000
4.6 II	4	69,000,000
4.6 III	2	79,200,000
4.6 IV	10	37,100,000
4.6 V	2	90,600,000
4.6 VII	8	106,300,000
4.6 VIII	1	26,800,000
4.6 IX	25	51,000,000
4.6 X	1	177,900,000

It is interesting to observe that the lowest recorded maximum, 27 millions in Cheese 4.6 VIII, and the highest, 178 millions per gram in Cheese 4.6 X, are in the two cheeses made in our own dairy from the milk of our own herd, having a very similar qualitative flora and ripening in a similar manner. The rate of ripening in these two cheeses was slightly different, the one with the highest maximum germ content ripening more slowly. The temperature to which Cheese 4.6 X was exposed while in the press was higher than in Cheese 4.6 VIII.

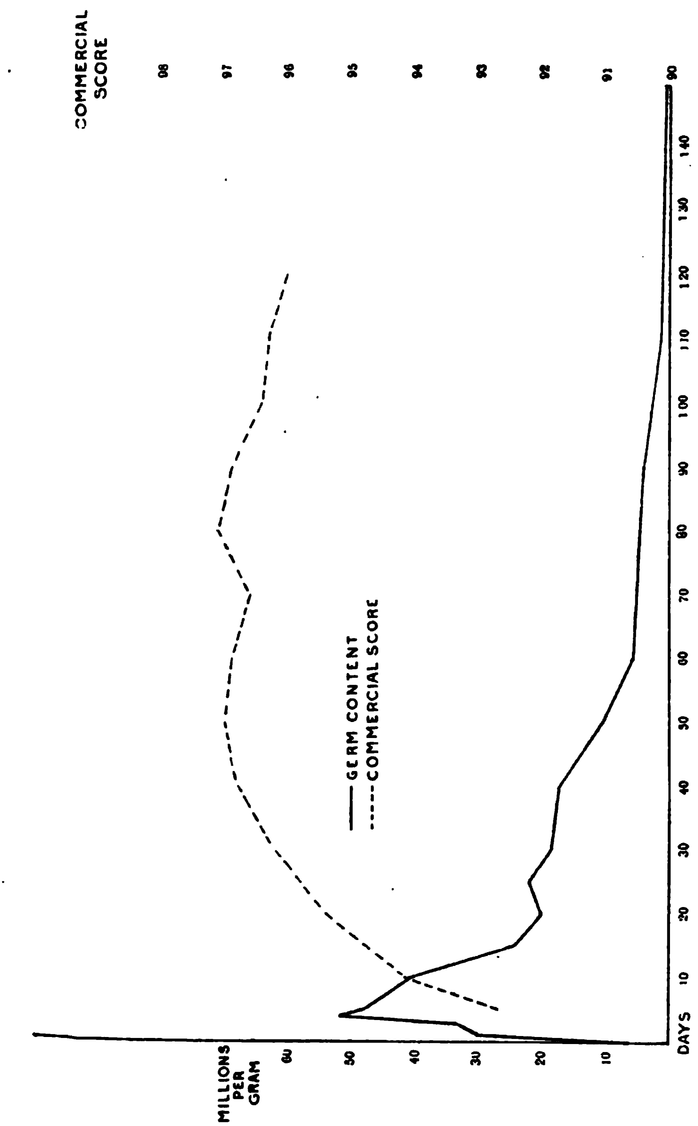
While, as we have seen, the changes in the germ content often differ widely in normal cheese, an average of all these observations has some value and is given in Table XXV.

TABLE XXV.—SHOWING THE AVERAGE GERM CONTENT OF ALL THE CHEESE EXAMINED AT GIVEN INTERVALS OF TIME.

Age of cheese.	Average of	Number of germs per gram.	Age of cheese.	Average of	Number of germs per gram.
Curd	4 cheeses	6,601,000	40 days	10 cheeses	17,100,000
5 hours	4 "	10,585,000	50 "	10 "	10,200,000
1 day	4 "	30,000,000	60 "	9 "	5,555,000
2 days	6 "	33,000,000	70 "	8 "	4,625,000
3 "	6 "	33,333,000	80 "	6 "	4,666,000
4 "	9 "	51,333,000	90 "	6 "	4,000,000
5 "	9 "	48,555,000	100 "	4 "	2,625,000
10 "	10 "	40,700,000	110 "	2 "	1,550,000
15 "	10 "	24,000,000	120 "	2 "	1,050,000
20 "	10 "	20,000,000	130 "	2 "	1,019,000
25 "	10 "	22,000,000	140 "	1 "	1,000,000
30 "	10 "	18,600,000	150 "	1 "	500,000

In computing this table there were included not only the results from the nine cheeses previously given but also those from an additional cheese which was made in our own dairy and studied during the process of manufacture. As the actual analyses were

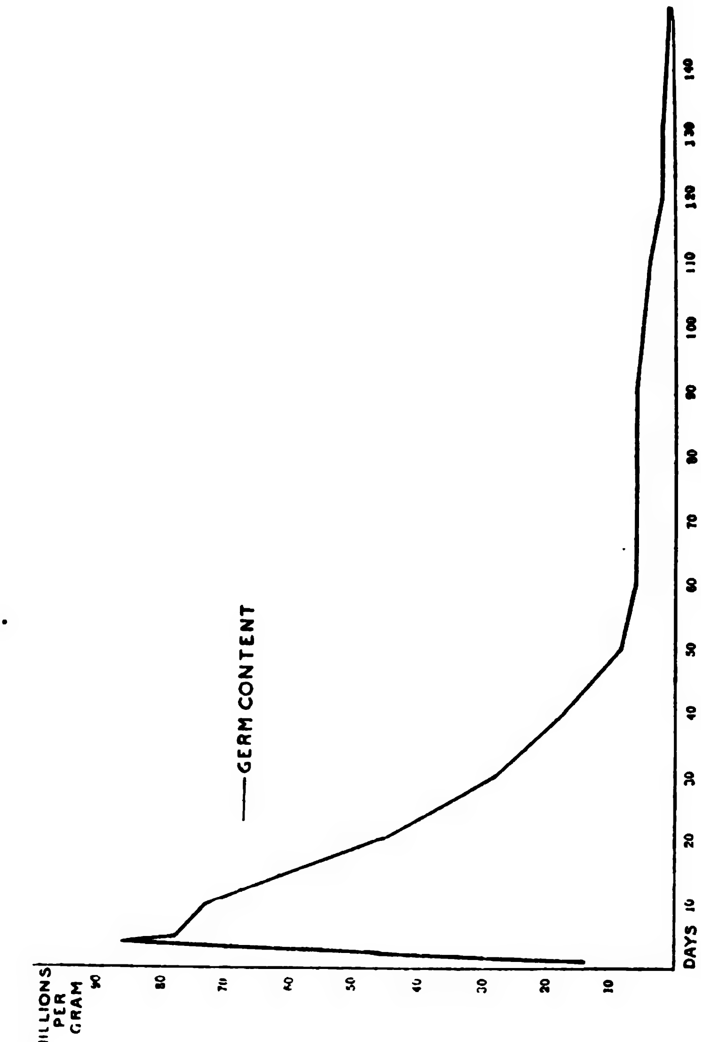
not always made at the exact intervals given in this table it was sometimes necessary to compute the germ content at such dates from the graph of the particular cheese. In view of the wide varia-



GRAPH X.—COMPOSITE GERM CONTENT OF TEN CHEESES AND COMPOSITE COMMERCIAL QUALITY OF SIX CHEESES.

tion in the individual cheeses this average must be considered merely as a schematic representation.

Graphical representation.— The numerical data given in Table XXV are shown in a different way in Graph X. This is on the same scale as those previously given; viz.: The ordinate is given in millions per gram while the abscissa is in days, the space allotted to 1 million germs being equal to that representing 1 day. The



GRAPH XI.—COMPOSITE GERM CONTENT OF SIX CHEESES ACCORDING TO RUSSELL.

number of cheeses is so small and the differences among them so marked that the graph is not smooth, the rise shown at 25 days being due to the late appearance of the maximum number in Cheese 4.6 IX at that age.

On the same graph is shown the average of the commercial scores of 6 of the cheeses. Here again the secondary rise shown at 80 days is due to the tardy ripening of Cheese 4.6 V. This graph brings out sharply the fact, observed in connection with each individual cheese, that there is a very considerable germ content in the cheese at the time when the latter has become commercially ripe.

For the sake of comparison the quantitative results on six cheeses as given by Russell & Weinzirl[26] are shown in Graph XI. The temperature of ripening in these two sets of cheeses was not the same and the observed numbers are higher in the second set but the outline of the graph in the two cases is very similar. Accordingly, these two graphs may be taken as fairly representing the average changes in germ content in normal cheddar cheese; but at the same time the fact must not be lost sight of that in the individual normal cheese the germ content may depart widely from this average. This is shown in Cheese 4.6 IX which showed a maximum content at twenty-five days instead of at four days as shown by the composite graphs.

A graph based on results from three Canadian cheddar cheeses was published by Harrison.[27] This curve reached a maximum of 450 millions per gram at 3 days and then promptly fell to less than 1 million at 57 days. Except for its amplitude this curve closely resembled the two which are here given.

QUALITATIVE SUMMARY.

Germs found.— When we remember that the milk from which the cheese is made receives substantial additions to its flora from the soil, the barn and the milking utensils it is natural to expect that the cheese will contain an extensive mixture of different forms. Notwithstanding the effort which was made to find the representatives of all the different forms present, the total number of distinct groups found in the nine cheeses which have been studied is surprisingly small. Over three hundred cultures were isolated from these cheeses, these selections being intended to include all differences in colony growth. These pure cultures were then studied both morphologically and culturally and in the course of this study many of the duplicates were discarded. The remaining one hundred sixty-seven cultures were studied in great detail and classified according

[26] See note 13.

[27] Harrison, F. C. The ripening of cheese and the role of microörganisms in the process. Trans. of the Canadian Institute, 7: 103-134. 1901.

to both the system of the Society of American Bacteriologists and that of Conn. All of the cultures thus studied are included in 33 groups, each characterized by a group number, or in 22 types.

While a long list of additional forms will undoubtedly be recognized in future studies of this field it is believed that this list of 33 groups includes those which will be most commonly found in normal cheddar cheese in New York State. The group number of these forms, their type name according to Conn and the number of the cheese from which they were isolated are given in Table XXVI. The period during which each form persisted in the cheese is also shown. This determination has been made in two slightly different ways and the results from each are given. The age of the cheese at the isolation of the culture whose group number was determined is indicated by + . In some cases the duplicate cultures mentioned above were isolated later in the history of the cheese than the one whose group number is positively known. In such cases the date of isolation of the duplicate culture is marked by o. We have every reason to think that the results expressed in Table XXVI by o are reliable while those shown by + are established beyond question.

It will be observed from this table that of the first 11 forms six are not recorded after the first day and the remaining five not after the second day. With a single exception each of these forms was found in but one of the nine cheeses. Under these circumstances it seems proper to consider these eleven groups as merely accidental members of the cheese flora, unsuited by nature to thrive in and exert an influence upon the ripening cheese.

Of the remaining groups eleven were found in but a single cheese but they persisted there a sufficient length of time to suggest that they might reasonably be included in the flora of typical cheddar cheese. Their infrequency of occurrence, however, makes it plain that they are not absolutely necessary to the progress of normal ripening.

Accordingly it is among the fourteen remaining groups that we must look for the portion of the cheese flora which exerts a marked influence upon the normal ripening processes. The important part played by the lactic organisms in the manufacture and early history of the cheddar cheese has been discussed at length in Bulletin 237.

The type *Bact. lactis acidi* makes up 99 per ct. or more of the flora of normal cheddar cheese in practically all cases. The rep-

resentatives of this type differ in their relation to air and in their ability to attack saccharose so that they are found under four different group numbers. As will be shown later they differ in a number of other particulars. *Str. lacticus,* which includes two differen group numbers, is occassionally found in much smaller numbers. These groups apparently agree with the corresponding groups of *Bact. lactis acidi* in every thing except morphology. The position taken by Conn, that there is a distinct morphological basis for the separation of the cocci from the rod forms, appears to be well taken. Both the morphology and the physiology of these groups is easily influenced by their environment and it is especially important that the cultures be brought to a vigorous condition before being subjected to detailed study.

The acid liquefiers which are considered so important by Gorrini are represented by *M. lactis albidus* (2 groups), *M. lactis giganteus, M. lactis varians* (4 groups), and *M. lactis brevis. M. lactis albidus* and *M. lactis brevis* occurred sufficiently often to suggest that they might play some part in the ripening changes. Representatives of this group were found in all but Cheese 4.6 VIII. These forms grew well in the milk but made little headway in the cheese although they survived there better than the non-acid-producing forms. Their number, as compared to the total germ content of the cheese, was relatively insignificant.

The gas-producing forms, like the preceding group, find the best conditions for their development in the milk and make little or no growth in the cheese. *B. coli aerogenes* was found in the milk for Cheeses 4.6 VIII and X. In both cases it was not found in the cheese after the first day. The isolated cultures were slow gas producers and did not displace more than one-third of the closed arm in the fermentation tube.

Bact. lactis aerogenes was found in Cheeses 4.6 IV, VIII, IX and X, in the last three in considerable numbers. In these cases evidence of gas was noted in the vat during the early stages of the making process. These forms are very resistant to the acidity in the milk and cheese but our data do not show that they multiply in the latter.

The inert group, characterized by a lack of any apparent action upon milk, is represented by *Galactococcus versicolor* and *Bact. lactis Connii.* They are fairly numerous at times in the milk and fresh curd. They usually disappear quickly. There is no evidence that they increase in the cheese.

TABLE XXVI.—OCCURRENCE AND DISTRIBUTION OF GERMS IN NINE NORMAL CHEDDAR CHEESES.

Group number.		Type Name (Conn).	Cheeses—Age in days	1	2	4	7	8	10	14	16	17	19	20	23	24	27	29	34	36	37	38	41	47	48	51	55	61	69	75	89	136
M.	211.23200	*M. lactis albidus*	X	+																												
Bact.	212.22200	*Bact. lactis acidi C*	VIII	+																												
M.	212.22200	*M. lactis acidi*	VIII	+																												
Bact.	212.33307	(Not listed by Conn)	VIII	+																												
M.	221.22200	*M. lactis albidus*	X	+																												
B	222.11100	*B. coli aerogenes*	VIII, X	+																												
M.	211.22206	*M. lactis giganteus*	IV		+																											
M.	211.22305	*M. lactis varians*	IV		+																											
Bact.	111.33305	*Bact. lactis chromatum*	VIII		+																											
Bact.	112.33305	*Bact. lactis aureum II*	VIII		+																											
Bact.	211.33310	*Bact. lactis album*	V		+																											
M.	211.33300	*M. lactis albus*	VIII	+		+																		O								
B.	112.33320	*B. lactis nebulus*	I				+																									
Bact.	212.22300	*Bact. lactis acidi D*	III				+																									
Bact.	211.33300	*Bact. lactis album*	VIII						+															O								
M.	211.22205	*M. lactis varians*	V						+																							
M.	211.33305	*M. lactis aureus A*	II, IV			+			+																		O					
M.	212.22205	*M. lactis aureus*	III, V				+		+																							
M.	212.22305	*M. lactis aureus*	IV						+																							
M.	211.22200	*M. lactis albidus*	III, V, IX	+	+					+																	O					
Str.	212.33300	*Galactococcus versicolor*	II, IX	+								+																				
Bact.	221.22220	*Bact. lactis brevis*	IV		+							+																				
Str.	212.22200	*Streptococcus lacticus*	III, IV, IX, X	+	+					+		+	+																			
Bact.	222.22220	*Bact. lactis acidi*	I, VII				+								+																	
M.	211.22215	*M. lactis varians*	IV									+				+																
Bact.	222.22320	*Bact. lactis acidi*	I												+				+													
Bact.	222.11100	*Bact. lactis aerogenes*	IV, VIII, IX, X	+														+	+													
Bact	212.33300	*Bact. lactis Connii*	III, VIII	+	+															+				O								
Str.	222.22200	*Streptococcus lacticus*	III, IV, V, VII				+					+							+		+											
Bact.	212.33300	*Bact. lactis viscosum*	VII, X	+																						+						
M.	221.22205	*M. lactis varians*	VII								+										+					+					O	
M.	212.33305	*M. lactis citreus B*	I, VII, IX			+															+									+		
Bact.	221.22200	*Bact. lactis brevis*	I, III, IX	+	+														+											+		
Bact.	122.22200	*Bact. lactis ubiquitum*	I																												+	
Bact.	222.22300	*Bact. lactis acidi*	I, IV, V, IX		+														+			+		+				+		+	+	
Bact.	222.22200	*Bact. lactis acidi*	I, II, III, IV, V, VII, IX, X	+	+	+		+			+	+		+			+		+		+		+	+	+		+	+	+	+	+	
Bact.	212.22200	*Bact. lactis acidi*	I, VII								+																					+
Bact.	212.22300	*Bact. lactis acidi*	I, IV, VII, VIII								+					+		+			+											+

Very few specimens of yeasts have been found although an effort was made to prepare plates especially suitable to their habits of growth.

Detailed description.— A weakness of previous studies of this subject, with the possible exception of that of Conn, has been the fact that the organisms were not described in such a manner that succeeding workers could recognize them. Accordingly each new student was compelled to study the flora anew and with little assistance from the previous work. Under such circumstances progress was necessarily slow.

With the recent improvement in the manner of recording the reactions of the cultures and of arranging this record for comparison it is believed that this difficulty has been largely overcome. Future students should be able to build upon the present foundation and a fairly complete knowledge of the cheese flora be made comparatively easy.

The group number expresses the spore formation, relation to oxygen, liquefaction, fermentation of dextrose, lactose and saccharose, nitrate reduction and color. There are many other relations to their environment with regard to which cultures will differ. The individual cultures have been tested with regard to a considerable number of these and the results are given in Table XXVII.

In this table the cultures are arranged in the numerical order of their group numbers. The type name according to Conn is given in all but a single case; Bact. 212.33307 did not seem to be included in the forms studied by him.

In addition to the facts expressed in the group number the observations upon the cultures in connection with 26 other items is recorded by + or —. The numerals at the left of these signs give the number of pure cultures found which were alike in these particulars.

Of the 148 cultures which were thus studied the 33 groups are subdivided into 93 variations or an average of less than two cultures to a variation. This illustrates on one hand the variation which is constantly met in bacteria from cheese and on the other the hopelessness of attempting to classify cultures into divisions which should include only members which are identical. Were the list of reactions sufficiently extended it is doubtful if two cultures could be found which would have an identical record.

System of nomenclature.— Throughout this bulletin the cultures have been designed according to both the Society card and the system of Conn. This is not the place for an extended discussion of the relative suitability of the reactions chosen for separating the groups or the types in the two systems. Any comprehensive study of that subject must be based upon an entirely different set of data from those accumulated in this work. On the other hand the simultaneous application of these two systems throughout this study has provided a good basis for comparing their relative utility in connection with such research.

There is practically no difference in the number of subcultures required to determine the group number or the type name. The group number may be obtained from data upon four different cultures (the new card calls for six) and in determining the type name seven cultures may be needed although a smaller number often suffices. For accurate results these cultures should be made in triplicate.

However, there is a marked difference in the number of detailed observations upon these cultures required by the two systems, those called for in fixing the group number being less than one-half as numerous as those necessary in separating the types. In recording the observations and in arranging the results for rapid comparison the present Society card leaves little to be desired.

In applying the classification of Conn it was observed that while there usually were uniform results different workers would sometimes include a culture under different types and even the same worker, on different days, would classify some cultures differently. Similar experiences have been noted by botanists when using a like system of classifying higher plants.

With the Society card, the facts having been determined, the new cultures fell into their allotted places with mathematical precision. The classification permitted only a single interpretation and errors in judgment were well nigh impossible. Not only was the accuracy much increased but the time required both to do the classification and to detect the duplicates was markedly shortened.

In the actual results of the classification by the two systems there is not a wide difference. The flora as determined is divided into 33 groups or 22 types. The classifications however are not strictly parallel. Bact. 212.22300 includes a section of *Bact. lactis acidi* and also *Bact. lactis acidi D.* However Conn considers *Bact. lactis acidi D.* as a variation of *Bact. lactis acidi* rather than as a distinct

TABLE XXVII.—DETAILED CHARACTERISTICS OF CULTURES ISOLATED FROM NINE NORMAL CHEDDAR CHEESES.

Group number.	Type Name (Conn).	Number of cultures.	Morphology.			Cultural Features. Broth.			Agar.		Gel. plate.					Gel. stab.			Potato.				Milk.					
			Diameter over 1 micron.	Chains.	Gram's stain.	Turbid.	Scum.	Sediment.	Shining.	Wrinkled.	Round.	Proteus-like.	Rhizoid.	Filamentous.	Curled.	Funnel.	Surface-growth.	Needle-growth.	Absent.	Abundant.	Discolored.	Growth at 37° C.	Digested.	Curdled.	Acid.	Alkaline.	Strong odor.	Indol.
Bact. 111.33305	*Bact. lactis chromatum*	1	+	—	+	+	+	+	—	—	—	—	—	—	—	+	+	+	—	+	—	+	+	+	—	+	—	
Bact. 112.33305	*Bact. lactis aureum II*	1	+	—	+	+	—	+	—	—	—	—	—	—	—	—	+	+	—	+	—	+	—	+	+	—	—	..
B. 112.33320	*B. lactis nebulus*	2	—	—	—	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	—	—	—	—	—
Bact. 122.22200	*Bact. lactis ubiquitum*	1	—	+	—	+	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	..
M. 211.22200	*M. lactis albidus*	4	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	..
		1	—	—	+	+	—	+	+	—	+	—	—	—	—	+	+	+	—	—	—	+	+	+	+	—	—	..
		1	+	—	+	+	+	+	+	—	+	—	—	—	—	+	+	+	—	—	—	+	+	+	+	—	—	..
M. 211.22205	*M. lactis varians*	1	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	..
M. 211.22206	*M. lactis giganteus*	1	+	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	..
M. 211.22215	*M. lactis varians*	1	—	—	+	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	+
		1	—	—	+	+	+	+	+	—	+	—	—	—	—	—	+	+	—	+	—	+	+	+	+	—	—	+
M. 211.22305	*M. lactis varians*	1	+	—	+	+	—	+	+	—	+	—	—	—	—	+	+	+	—	—	—	+	+	+	+	—	—	+
M. 211.23200	*M. lactis albidus*	1	+	+	+	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	..
Bact. 211.33300	*Bact. lactis album*	1	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	+	+	+	+	—	—	+	—	..
M. 211.33300	*M. lactis albus*	1	—	+	+	+	—	+	+	—	+	—	—	—	—	+	+	+	—	—	—	+	+	—	—	+	—	..
		1	+	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	—	—	+	—	..
M. 211.33305	*M lactis aureus A*	1	+	—	—	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	—	—	+	—	..
		1	+	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	+
Bact. 211.33310	*Bact. lactis album*	1	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	—	—	+	—	+
Bact. 212.22200	*Bact. lactis acidi*	1	—	—	—	+	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	..
		1	—	—	+	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	—	+	—	—	..
Bact. 212.22200	*Bact. lactis acidi C*	1	—	—	+	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	—	+	—	—	..
M. 212.22200	*M. lactis acidi*	1	—	—	+	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	—	+	—	—	..
Str. 212.22200	*Streptococcus lacticus*	2	—	—	+	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	.	+	+	—	—	..
		1	—	—	+	—	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	+	+	—	—	—
		1	—	—	+	+	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	—	+	—	—	..
		1	—	+	—	—	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	+	+	—	—	..
		1	+	+	+	+	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—

M.	212.22205	*M. lactis aureus*	1	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	+	+	+	—	—	+	—	—	:
			1	—	—	+	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	—	—	—	—	—
Bact.	212.22300	*Bact. lactis acidi D*	1	—	—	—	+	+	+	+	—	+	—	—	—	—	—	+	+	—	+	+	+	—	—	+	—	—	:
Bact.	212.22300	*Bact. lactis acidi*	1	—	—	—	+	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	:
			2	—	—	+	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	:
			2	—	—	+	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—
			1	+	+	—	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	+	+	—	—	:
M.	212.22305	*M. lactis aureus*	1	—	—	+	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	—	+	—	—	+
Bact.	212.33300	*Bact. lactis Connii*	1	—	—	—	+	—	+	—	—	+	—	—	—	—	—	+	+	—	+	+	+	—	—	—	+	—	:
			1	—	+	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	+	—	+	—	+	+	—	—	:
			1	+	—	—	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	+	+	—	—	—	+	—	:
Bact.	212.33300	*Bact. lactis viscosum*	3	—	—	—	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	—	—	+	—	:
			1	+	—	—	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	—	—	+	—	+
			1	+	+	—	+	—	+	+	—	—	—	—	—	—	—	+	+	—	—	—	+	—	—	—	+	—	+
			1	+	+	—	+	—	+	+	—	—	—	—	—	—	—	+	+	—	+	—	+	—	—	—	+	—	+
Str.	212.33300	*Galactococcus versicolor*	1	—	—	—	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	—	—	—	—	:
			1	—	—	—	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	—	+	—	—	:
M	212.33305	*M. lactis citreus B*	1	—	—	—	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	+	+	—	—	—	—	—	:
			1	—	—	+	+	+	+	+	—	+	—	—	—	—	—	+	+	—	+	—	+	—	—	—	—	—	:
			1	—	—	+	+	+	+	+	—	+	—	—	—	—	—	+	+	—	+	+	+	—	—	+	—	—	:
Bact.	212.33307.	(Not listed by Conn)	1	+	—	—	+	—	—	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	—	—	—	—	:
Bact.	221.22200	*Bact. lactis brevis*	1	—	—	—	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	:
			4	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	:
M.	221.22200	*M. lactis albidus*	2	+	+	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	:
M.	221.22205	*M. lactis varians*	2	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	:
			1	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	—
			1	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	+	—	+	+	+	+	—	—	:
Bact.	221.22220	*Bact. lactis brevis*	1	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	:
			1	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	+	+	+	—	—	+
Bact.	222.11100	*Bact. lactis aerogenes*	1	+	—	—	+	—	+	+	—	+	—	—	—	—	—	+	+	—	+	—	+	—	+	+	—	—	+
			3	+	—	—	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	+	+	—	—	+
			3	+	—	—	+	+	+	+	—	+	—	—	—	—	—	+	+	—	+	—	+	—	+	+	—	—	+
			1	+	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	+	—	+	—	+	+	—	—	+
			1	+	—	+	+	+	+	+	—	+	—	—	—	—	—	+	+	—	+	—	+	—	+	+	—	—	+
B.	222.11100	*B. coli aerogenes*	1	—	—	—	+	+	+	+	—	+	—	—	—	—	—	+	+	—	+	—	+	—	+	+	—	—	:
			1	+	+	—	+	+	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	—	+	—	—	+
Bact.	222.22200	*Bact. lactis acidi*	1	—	—	—	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	—	—	+	+	—	—	:
			3	—	—	—	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	:
Bact.	222.22200	*Bact. lactis acidi*	3	—	—	—	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—
			3	—	—	—	—	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	—	—	+	+	—	—	:
			6	—	—	—	—	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	:
			4	—	—	—	+	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	—	—	+	+	—	—	:
			4	—	—	—	+	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	:
			1	—	—	—	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	+	+	—	—	:
			3	—	—	+	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	:
			6	—	—	+	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—
			1	—	—	+	—	—	—	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	+	+	—	—	:
			2	—	—	+	—	—	—	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	+	+	—	—	—
			3	—	—	+	—	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—
			1	—	—	+	+	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	:

TABLE XXVII.— DETAILED CHARACTERISTICS OF CULTURES ISOLATED FROM NINE NORMAL CHEDDER CHEESES — *Continued.*

Group number.	Type Name (Conn).	Number of cultures.	Morphology.			Cultural Features.																							
						Broth.			Agar.		Gel. plate.					Gel. stab.			Potato.				Milk.						
			Diameter over 1 micron.	Chains.	Gram's stain.	Turbid.	Scum.	Sediment.	Shining.	Wrinkled.	Round.	Proteus-like.	Rhizoid.	Filamentous.	Curled.	Funnel.	Surface-growth.	Needle-growth.	Absent.	Abundant.	Discolored.	Growth at 37° C.	Digested.	Curdled.	Acid.	Alkaline.	Strong odor.	Indol.
		3	—	—	+	+	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	+	+	—	—	:
		1	+	+	+	+	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—
Str. 222.22200	*Streptococcus lacticus*	3	—	—	+	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—
		1	—	—	+	+	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	:
		1	—	+	+	—	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—
Bact. 222.22220	*Bact. lactis acidi*	1	—	—	—	—	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	—	—	+	+	—	—	—
		2	—	—	+	—	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—
		1	—	—	+	+	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—
Bact. 222.22300	*Bact. lactis acidi*	1	—	—	—	—	—	—	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	+	+	—	—	—
		5	—	—	—	—	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	:
		1	—	—	—	—	—	+	+	—	+	—	—	—	—	—	+	+	—	—	—	+	—	+	+	—	—	:
		2	—	—	+	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	:
Bact. 222.22320	*Bact. lactis acidi*	2	—	—	—	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	:
		1	—	—	—	—	—	—	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—
		1	—	—	—	—	—	+	+	—	+	—	—	—	—	—	—	+	—	—	—	+	—	+	+	—	—	—

type. Again Bact. 212.33300 includes *Bact. lactis Connii* and *Bact. lactis viscosum*. These two types are considered by Conn as differing mainly in viscosity and this item does not enter into the group number but is recorded in the body of the Society card. In both of these cases it is possible that a determination of the nitrate reduction might remove the apparent conflict.

On the other hand a type name according to Conn often includes germs answering to two or more group numbers. Thus *M. lactis varians* includes M. 211.22205; M. 211.22215 and M. 221.22205; *M. lactis albidus* includes M. 211.23200, M. 211.22200 and M. 221.-22200; *Streptococcus lacticus* includes Str. 212.22200 and Str.222.-22200; *Bact. lactis acidi* includes Bact. 212.22200, Bact. 222.22220 and Bact. 222.22320; *M. lactis aureus* includes M. 212.22205 and M. 212.22305. An improvement in the details of the group number is desirable and will come, but even as it now stands the Society card system is a distinct advance over anything which has preceded it.

CONCLUSIONS.

The system of recording the reactions of cultures as proposed by the Society of American Bacteriologists is a marked advance in technique. By its aid the shifts in the cheese flora can be followed with more accuracy than was previously possible. The cultures isolated can readily be so characterized as to be recognized by succeeding workers. Each investigator can thus build upon what has been done and a satisfactory acquaintance with such of the flora as will grow on our culture media is possible at no very remote date.

The quantitative changes observed in nine normal cheeses, representing four commercial factories and our own dairy, agree closely with those previously found in Wisconsin and Canada. Emphasis should be laid upon the fact that first class cheeses vary widely both in their total germ content and in the age at which the maximum number of bacteria is found. A parallel study of the flora and of the commercial quality brought out the fact that at the time the cheese was commercially ripe it ordinarily contained some millions of living bacteria per gram.

The qualitative study showed that the *Bacterium lactis acidi* of Leichmann is the only form which is constantly found in all of the cheddar cheese which has been studied. Representatives of this form are arranged under four different group numbers and it is highly probable that these groups mark distinct strains of *Bacterium lactis acidi*.

The general group of acid-forming, liquefying organisms is represented at practically all times but in such small numbers as to suggest that the group exerts little influence upon the ripening changes.

The rate of the ripening process seems to be independent of the number of germs present except that in certain cheeses a flora closely confined to acid-producing forms was coincident with a retarded rate of ripening.

There is a lack of satisfactory evidence, either in the results from our studies or in those which have preceded them, that any of the forms thus far isolated play an important part in the later stages of the ripening of normal cheddar cheese. This does not preclude the possibility that such evidence may be later produced nor that important forms may be found which do not appear upon our present culture media.

REPORT OF THE DEPARTMENT OF BOTANY.

F. C. Stewart, *Botanist.*
G. T. French, *Assistant Botanist.*
J. G. Grossenbacher, *Assistant Botanist.*
F. A. Sirrine, *Special Agent.*

TABLE OF CONTENTS.

Investigations on some fruit diseases.
The Sporotrichum bud-rot of carnations and the silver top of June grass.
Troubles of alfalfa in New York State.
Potato spraying experiments in 1907.

REPORT OF THE DEPARTMENT OF BOTANY.

INVESTIGATIONS ON SOME FRUIT DISEASES.*

H. J. EUSTACE.

SUMMARY.

Apples artificially inoculated with decay-producing fungi were placed in commercial cold storage, temperature 32° F., and held there for two months or more. Of the several species used, Penicillium glaucum (blue mold), was the only one that developed and caused decay. Upon removal to a warmer temperature all the speceis of fungi developed and caused decay.

Decay was not entirely prevented in inoculated apples held in a temperature of 35° to 56°; and developed vigorously in a temperature of 48° to 69°.

Peaches inoculated with Sclerotinia fructigena (brown rot), the most common and destructive decay of peaches, developed a small amount of decay in two weeks in a temperature of 32° F.

Spores of Penicillium glaucum (blue mold), can be destroyed by fumigation with sulphur, but when these fumes come in contact with ripe apples the commercial value of the fruit is lessened.

Spraying immature apples with bordeaux mixture did not check the development of spots of Venturia inæqualis (scab), that had started previous to the application of the bordeaux mixture.

*A reprint of Bulletin No. 297.

I. APPLE ROTS IN COLD STORAGE.

Since the commercial cold storage of apples has become such an important industry in New York State many questions relating to it have demanded solution. Many of these questions have been studied experimentally, and definite knowledge of great practical value regarding them determined.

However, the question as to whether the several species of fungi that most commonly cause the decay of fruit will develop and produce decay in fruit while held in commercial cold storage has never been studied.

Since disputes over the condition of fruit held in commercial cold storage houses are frequent and sometimes find their way into court, it is highly desirable to have some reliable information as to the troubles that are directly traceable to the growth of certain well known fungi.

The methods of conducting the experiments upon this question were to obtain a good supply of pure cultures of the fungi, from these to make inoculations under sterile conditions into sound apples and to place the fruits at once in a commercial cold storage house. After remaining there a reasonable time they were removed into a warmer temperature.

Experiments were carried on in the winter of 1905 in duplicate, but in different cold storage houses. Higher temperatures were also experimented with; one from 37° to 56° F., the average being 47° F.; and another from 54° to 65.5° F., the average being 60.6° F. The work with commercial cold storage at different temperatures was repeated in the winter of 1906 in one house.

THE EXPERIMENTS OF 1905.

A good supply of vigorous pure cultures of bitter rot (*Glomerella rufomaculans* (Berk.) Sp. & vonSchr.), black rot (*Sphæropsis malorum* Pk.), blue mold (*Penicillium glaucum* Lk.), brown rot (*Sclerotina fructigena* (Pers.) Schrt.), pink rot (*Cephalothecium roseum* Cda.) and *Alternaria* sp. were secured by taking apples that were naturally infected with these fungi and with some of the mature spores making dilution or poured plate cultures with

potato agar. From these plates transfer cultures were made to sterilized sugar beet plugs and from these several sub-cultures were made. These last cultures were then tested to make sure of their pathogenicity.

Sound mature apples of the following varieties were selected for the inoculations: Baldwin, Tompkins King, Northern Spy, Rhode Island *Greening,* Russet and Sutton. Each fruit was cleaned with a cloth and then dipped in a solution of corrosive sublimate 1 : 1000; from this it was drained and rinsed in clean distilled water, drained again and the excess moisture absorbed with a cloth that had been wet with corrosive sublimate and dried.

Several fruits of each variety were inoculated with each species of fungus used.

The inoculations were made on March 9, 1905. On each fruit the epidermis was punctured in three places with a sterile knife and with another sterile knife some of the fungus from a pure culture was inserted in the puncture.

In connection with the inoculation experiments it was thought desirable to test the power of these species of fungi to grow in culture. This was done by preparing a quantity of petri dishes of sterile agar and transferring, under sterile precautions, some of the fungus from the pure cultures to several places upon the agar. The apples inoculated with a single species of fungus were put together and packed in a separate compartment in a bushel box. The plate cultures were wrapped in clean paper and packed in with the apples. Immediately after completing the work the boxes were taken by a special messenger to a commercial cold storage plant and at once placed in a room where the temperature was 31° F. Records of the temperature in this room were taken six times each day at regular intervals. The record gave 360 readings during the time the experiment was in progress; 3 were 29°, 1 was 29½°, 97 were 30°, 75 were 30½°, 143 were 31°, 37 were 31½°, and 4 were 32°.

The apples and cultures were all removed from the cold storage house on May 9 and examined that day. The results were as follows:

TABLE I.— CONDITION OF INOCULATED APPLES AND CULTURES AFTER BEING IN COLD STORAGE TWO MONTHS.

FIRST TEST.

Fungus.	Growth in apples.	Growth in cultures.
Alternaria sp.	No growth in any of the fruits.	Slight growth.
Bitter rot, *Glomerella rufomaculans.*	No growth in any of the fruits.	No growth.
Black rot, *Sphæropsis malorum.*	No growth in any of the fruits.	No growth.
Blue mold, *Penicillium glaucum.*	An area of decay more than an inch in diameter has developed at every point of inoculation.	Small growth in all the petri dishes.
Brown rot, *Sclerotinia fructigena.*	No growth in any of the fruits.	No growth.
Pink rot, *Cephalothecium roseum.*	No growth in any of the fruits.	No growth.
Scab, *Venturia inæqualis.*	No experiments with fruit.	Slight growth in the dishes and on sugar beet plugs.

The condition of the apples is shown in Plate III, which is a reproduction of a photograph made the same day the fruit was removed from cold storage.

After making the notes and the photograph the apples were placed in a room where the temperature was about 70° F. during the day but somewhat less at night. Notes on the progress and development of the decay were made on May 16 and 23, the conditions being as follows:

TABLE II.— CONDITION OF INOCULATED APPLES REMOVED FROM COLD STORAGE TO WARM TEMPERATURE.

FIRST TEST.

Fungus.	Condition on May 16.	Condition on May 23.
Alternaria sp.	Decay has developed about the point of inoculation on all fruits.	Decay has continued to develop in every case.
Bitter rot, *Glomerella rufomaculans.*	Decay area about ½ inch in diameter has developed about the point of inoculation on all fruits.	Decay has continued to develop. Fungus is fruiting freely.
Black rot, *Sphæropsis malorum.*	Decay has developed to small extent.	Decay has affected about one-half of each fruit.
Blue mold, *Penicillium glaucum.*	Decay developed vigorously.	Decay spread over entire fruit.
Brown rot, *Sclerotinia fructigena.*	Decay developed vigorously in all varieties except Northern Spy, on which it has made small development, fungus fruiting most abundantly on Baldwin and R. I. *Greening.*	Decay spread over entire fruit.
Pink rot, *Cephalothecium roseum.*	Decay has developed at the point of inoculation in each case.	Decay developed considerable fungus on some apples.

Plate IV shows the condition of the apples on May 23.

The duplicate of this experiment was prepared on March 13, 1905. The same species of fungi and the same varieties of apples were used. The details of the inoculations were the same. A different cold storage house was used. A few hours after the inoculations were made in the laboratory the apples were stored in

this house, being taken there by messenger. The temperature was recorded at different periods four times each twenty-four hours. An examination of these records shows that at 4 readings the temperature was 30°, at 3 it was 30½°, at 45 it was 31°, at 74 it was 31½°, at 90 it was 32°, at 25 it was 32½° and at 4 it was 33° F.

The apples and cultures were removed from the cold storage house on May 13, 1905, and at once brought to the laboratory by messenger and immediately examined. Their condition was as stated in the following table:

TABLE III.— CONDITION OF INOCULATED APPLES AND CULTURES AFTER BEING IN COLD STORAGE FOR TWO MONTHS.

SECOND TEST.

Fungus.	Growth in apples.	Growth in cultures.
Alternaria sp.	On some fruits there has been a slight growth, but nothing of importance.	No growth.
Blue mold, *Penicillium glaucum.*	Large decayed spots at the point of every inoculation.	Vigorous colonies in each culture.
Brown rot, *Sclerotinia fructigena.*	No growth in any of the fruits.	No growth.
Pink rot, *Cephalothecium roseum.*	No growth in any of the fruits.	No growth.
Scab, *Venturia inœqualis.*	No experiments with fruit.	Small growth in the cultures.

The condition of these apples and cultures upon removal from the cold storage house was the same as those in the first experiment. The experiments were comparable in every way and the results are practically identical.

As was done in the first experiment, the apples were photographed and then put away in a place at room temperature — about 70° during the day. They were examined in one week and again in two weeks, their condition being as follows:

TABLE IV.— CONDITION OF INOCULATED APPLES REMOVED FROM COLD STORAGE TO WARM TEMPERATURE.

SECOND TEST.

Fungus.	Condition on May 20.	Condition on May 27.
Alternaria sp.	Small decayed spots at the points of inoculation.	Decay has continued to develop.
Bitter rot, *Glomerella rufomaculans.*	Small decayed spots at point of every inoculation. Fungus fruiting on some.	Decayed spots have enlarged.
Black rot, *Sphæropsis malorum.*	Decay has developed at point of every inoculation.	Most of the fruits entirely decayed.
Blue mold, *Penicillium glaucum.*	Large part of every fruit has decayed.	Decay has spread.
Brown rot, *Sclerotinia fructigena.*	Decayed area of good size at nearly every point of inoculation.	Decay has spread.
Pink rot, *Cephalothecium roseum.*	Decay has started at the point of inoculation in most cases.	Decay has continued to develop.

These results agree in every respect with those of the first experiment and again demonstrate that the low temperature does not destroy the fungus, but simply retards its germination and growth.

THE EXPERIMENTS OF 1906.

The next year, the winter of 1906, another similar experiment was made. The same cold storage house was used as in the first experiment.

Pure cultures of the species of fungi used were obtained by making dilution plate cultures from material secured from natural infections. From these, sub-cultures on sugar beet plugs were made and the inoculations made from the last one after its pathogenicity had been tested.

Nine varieties of apples were used, some of each variety being inoculated with each species of fungus used. The usual precau-

tions were taken to clean the fruit before the inoculations and to use sterile instruments in doing the work.

Immediately after the inoculations were made the fruit was taken by messenger to the cold storage house and placed at once in a room that contained other fruit where the temperature was 32° F.

The varieties used were Swaar, Fall Pippin, Twenty Ounce, Winter Banana, Deacon Jones, Fameuse, Reinette Pippin, Dickinson and Water. The same species of fungi were used as before, together with a few other species of no commercial importance.

The inoculations were made and the fruit placed in the cold storage house on January 18, 1906. It was removed, brought to the laboratory at Geneva, photographed and examined on March 22, thus being in the storage house 9 weeks.

The condition of the fruit upon its removal was as indicated in the following table:

TABLE V.—CONDITION OF INOCULATED APPLES AFTER BEING IN COMMERCIAL COLD STORAGE FOR NINE WEEKS.

THIRD TEST.

Fungus.	Growth in fruit.
Alternaria sp.	Decay has started at point of inoculation, but of very slight development.
Bitter rot, *Glomerella rufomaculans.*	Fruits all sound.
Black rot, *Sphæropsis malorum.*	Fruits all sound.
Blue mold, *Penicillium glaucum.*	Decay has started at all the points of inoculation, except in one fruit.
Brown rot, *Sclerotinia fructigena.*	Fruits all sound.
Pink rot, *Cephalothecium roseum.*	Fruits all sound.

These results agree with the previous experiments.

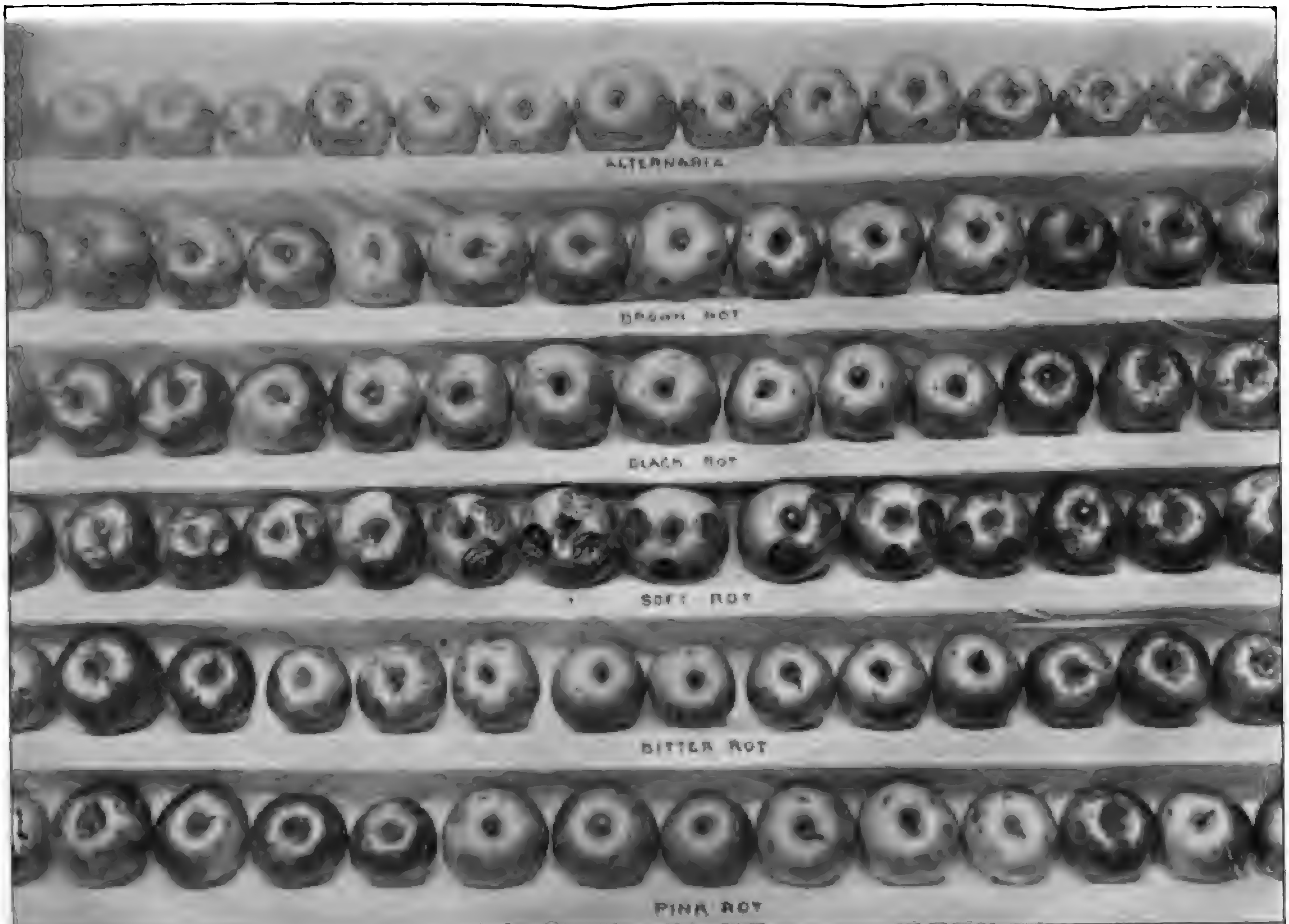


PLATE III. — CONDITION OF INOCULATED APPLES WHEN REMOVED FROM COLD STORAGE WAREHOUSE.

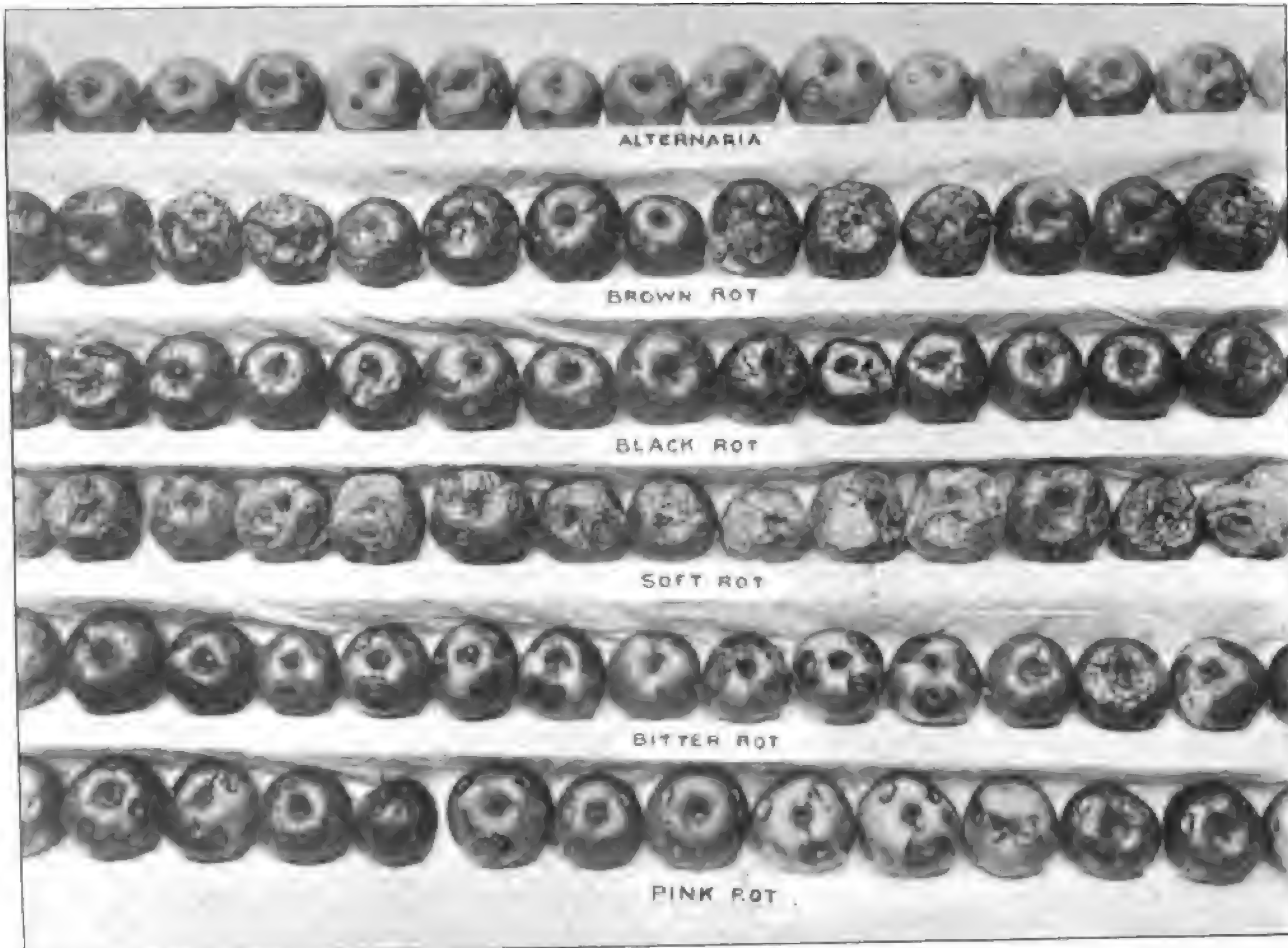


Plate IV. — Condition of Apples Shown in Plate III after They Had been in a Warm Room for Two Weeks.

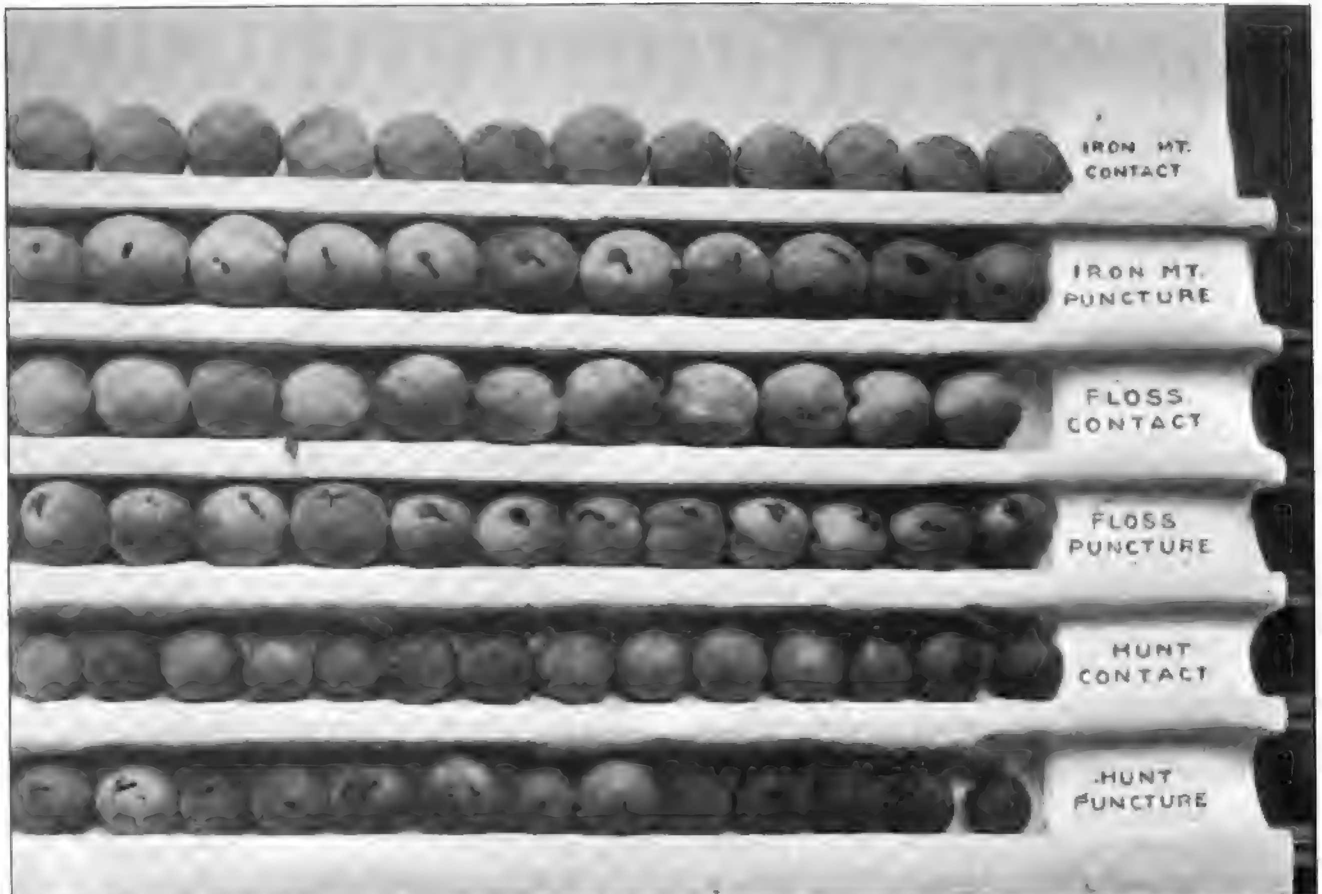


PLATE V. — CONDITION OF INOCULATED PEACHES WHEN REMOVED FROM A COLD STORAGE WAREHOUSE.

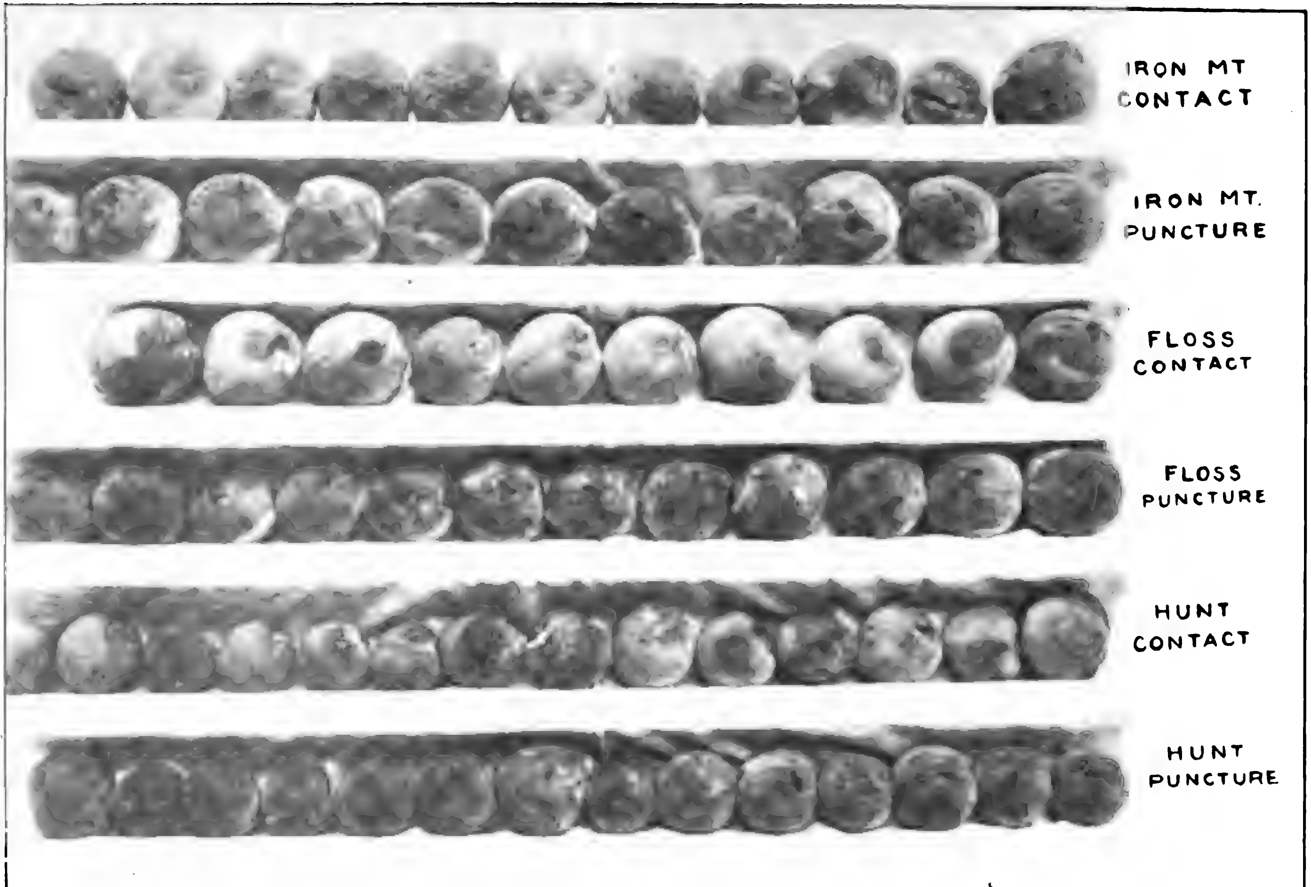


PLATE VI. — CONDITION OF PEACHES SHOWN IN PLATE V AFTER THEY HAD BEEN IN A WARM ROOM FOR TWO WEEKS.

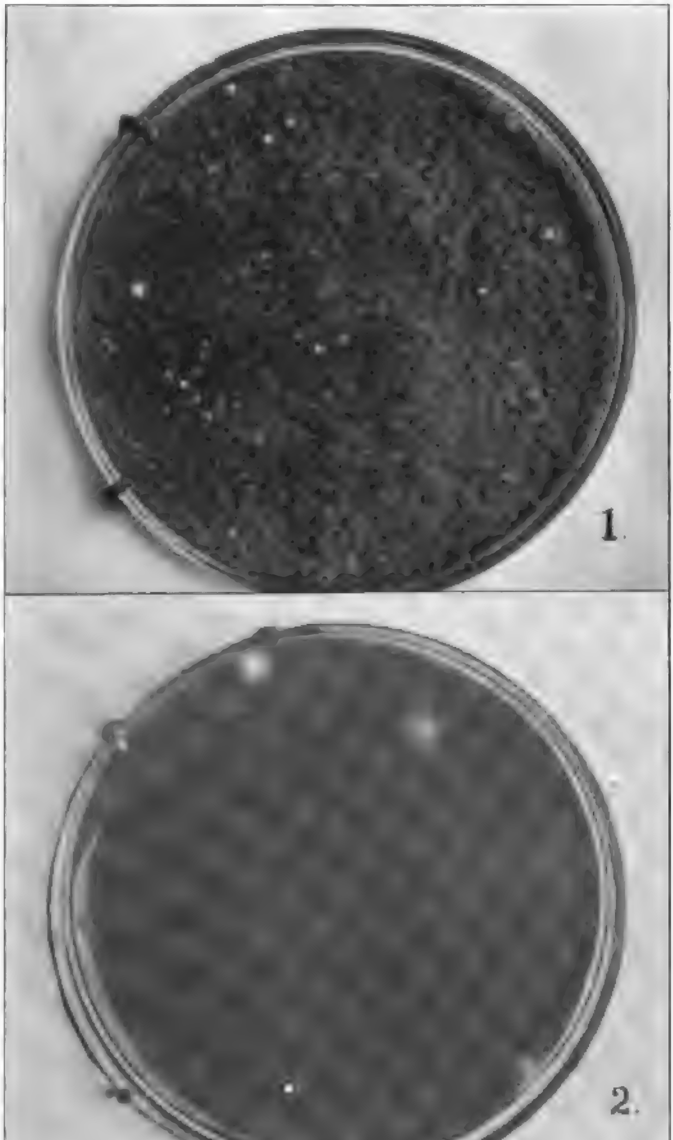


Plate VII. — Penicillium glaucum Spores Destroyed by Sulphur Fumigation. Petri Dishes of Sterile Agar were Exposed on the Floor of a Room One-half Hour after Spores of Fungus were Diffused through the Air: 1, Before Fumigation of Apples; 2, After Fumigation of Apples.

FIG. 1

FIG. 2

PLATE VIII. — APPLES INJURED BY SULPHUR FUMIGATION: 1, ESOPUS SPITZENBURG APPLE INJURED IN SOME UNKNOWN WAY (PROBABLY BY SULPHUR FUMIGATION); 2, ESOPUS SPITZENBURG APPLE INJURED BY SULPHUR FUMIGATION.

PLATE IX. — BOX OF ESOPUS SPITZENBURG APPLES INJURED IN SOME UNKNOWN WAY (PROBABLY BY SULPHUR FUMIGATION); 2, SCAB SPOT OF APPLE, MUCH ENLARGED, SHOWING THE MANNER OF GROWTH BENEATH THE EPIDERMIS.

As was done in the other cases, the fruits were placed in a room where the temperature was about 60° F. during the day and somewhat less during the night.

At the end of one and two weeks the conditions were as follows:

TABLE VI.— CONDITION OF INOCULATED APPLES REMOVED FROM COLD STORAGE TO WARM TEMPERATURE.

THIRD TEST.

Fungus.	Condition of the fruit on March 31.	Condition of the fruit on April 7.
Alternaria sp.	Decayed spots enlarged in most of the fruits.	Decayed spots have continued to enlarge. Fungus is fruiting.
Bitter rot, *Glomerella rufomaculans.*	Slight decayed areas.	Decay developing and fungus fruiting at nearly every point of inoculation.
Black rot, *Sphæropsis malorum.*	Slight decayed areas.	Decay areas enlarging.
Blue mold, *Penicillium glaucum.*	Large decayed areas on all of the fruits.	All fruits completely decayed.
Brown rot, *Sclerotinia fructigena.*	Large decayed areas on most of the fruits.	Every fruit more than one-half decayed.
Pink rot, *Cephalothecium roseum.*	Fungus is growing, but decayed spots are small.	Fungus is growing and causing decay.

These results were also the same as in the previous experiments. These experiments were made with the same species of fungus, using an assortment of varieties of apples, and the results are consistent in all cases. None of the fungi used proved to be capable of developing in the low temperature except the blue mold, *Pencillium glaucum,* which grew sparingly. The low temperature did not destroy any of the fungus spores, but simply retarded their germination. Upon removal to a higher temperature germination took place and decay of the fruit tissue resulted.

This inoculated fruit was in cold storage for two months or a little longer. It is possible, though not probable, that some of the species of fungi used would have developed and produced decay if the time had been extended.

All of the apples used in these experiments were kept in cold storage until shortly before being inoculated and hence did not go into the storage house in a warm condition. Had they been warm when they were placed in storage the kind of package used (bushel boxes) would have been quite important, for the fruit in a small package will cool down comparatively soon after going into a cool room. When large packages (barrels) are used, and the apples are warm, those in the center do not cool down to the temperature of the air of the room for some days.

Occasionally, barrels of apples are removed from cold storage and upon examination some of the fruit is found to be in a partly decayed condition, produced by the growth of some of the species of fungi that the preceding experiments have shown to be incapable of growing in the low temperature of a cold storage house. Assuming that the storage house was properly operated, such a condition of the fruit upon removal can be accounted for in two ways: (1) The apples may have been barreled and allowed to remain in the orchard or a shed or were on a railroad for some time. (2) It is possible also that decay would be found in barrels of apples that had been stored immediately after harvesting, if the weather at the time was warm. Under such conditions the fruits would go into the barrel warm and would be surrounded by warm air, and if the temperature of the fruit or air was 75° or 80° F. it would require about a week before the temperature of the fruit in the center of the barrel would be reduced to or near the temperature of the store room. But during the time the fruit was cooling decay could start and develop to some extent. Especially would this be true with a decay which develops quickly like bitter rot.

It is unfortunate that the only fungus that grows and produces decay in commercial cold storage is the most destructive and also most common species. But this rot is what might properly be termed a mechanical one, as the losses from it most often follow mechanical injuries to the fruit. Proper and careful handling will greatly reduce these injuries and therefore lessen the amount of decay from this rot.

AN EXPERIMENT IN TEMPERATURE OF 35° TO 56°.

An experiment similar to the previous one was made where the inoculated apples were placed in a temperature of from 35° to 56° F., the average being 47° F., determined by a maximum and mininum thermometer.

The same species of fungi were used as in the previous work and the varieties of apples were King, Baldwin, Rhode Island *Greening,* Northern Spy, Russet and Sutton.

The details of preparing the cultures, treating the apples and making the inoculations were the same as in the other experiments.

After the apples had been in this temperature for five weeks they were examined and all those inoculated with *Alternaria* sp., *Glomerella rufomaculans* (bitter rot) and *Sphæropsis malorum* (black rot) had developed decay spots ½ to 1 inch in diameter at the point of inoculation. The decayed spots in the apple inoculated with *Cephalothecium roseum* (pink rot) were smaller. Three-fourths of every apple inoculated with *Penicillium glaucum* (soft rot) was decayed. The culture of *Sclerotinia fructigena* (brown rot) which was used seemed to have lost its pathogenicity and the apples inoculated with this did not decay.

Petri dish cultures on potato agar were also made at the time the apples were inoculated and kept in the same room with the apples. In all of these cultures good growth of the different species of fungi developed.

At the end of the 5 weeks the apples were removed to a higher temperature and the decays developed rapidly.

AN EXPERIMENT IN A TEMPERATURE OF 48° TO 69°.

Another experiment was made, conducted in the same way as the previous ones, using a temperature of from 48° to 69° F., the average being 60.7° F., determined by a maximum and minimum thermometer.

At the end of 3 weeks the apples inoculated with *Alternaria* sp. and *Cephalothecium roseum* (pink rot) showed small decayed spots at the point of inoculation.

Those inoculated with *Sphæropsis malorum* (black rot), *Sclerotinia fructigena* (brown rot) and *Penicillium glaucum* (blue mold) were practically all decayed.

Those inoculated with *Glomerella rufomaculans* (bitter rot) showed decayed spots 1 to 2 inches in diameter at the point of each inoculation.

II. PEACH ROT IN COLD STORAGE.

The most severe and common decay of mature peaches is caused by *Sclerotinia fructigena* (brown rot). Since peaches are frequently put in commercial cold storage warehouses it was thought advisable to have some data regarding the behavior of this fungus in the temperature of the storage house.

Pure cultures of the fungus were secured by making dilution cultures with material from naturally infected fruit.

The varieties of peaches used were Iron Mountain, Floss and Hunt. A quantity of the fruit was secured and one-half of each variety inoculated by injecting some of the fungus from the pure culture beneath the skin. The other fruits were inoculated by contact which was done by first rolling them over paper moistened with distilled water and then over a quantity of the spores secured from several natural infections.

Immediately after the inoculations were made the fruits were taken by messenger to a commercial cold storage house in which the temperature was held at 32° F.

At the end of two weeks all of the fruits were removed and examined. Of those inoculated by puncture the conditions were as follows: Iron Mountain, 65 per ct. of fruits showed decayed spot ½ inch or less in diameter at the point of inoculation, 35 per ct. were entirely sound; Floss, 81 per ct. of the fruits showed decayed spot ¾ inch or less at point of inoculation, 19 per ct. were entirely sound; Hunt, 56 per ct. showed decayed spot ½ inch or less at point of inoculation, 44 per ct. were entirely sound. The condition of some average specimens of these fruits is shown in Plate V.

None of the fruits inoculated by contact showed any decay at the end of two weeks.

When the fruits were taken out of cold storage they were kept in a room where the temperature was rather low, so the decay did not develop rapidly. But at the end of ten days the fruits inoculated by puncture were all decayed. Those inoculated by contact were as follows: Iron Mountain, all of the fruits decayed; Floss, 71 per ct. decayed, 29 per ct. sound; Hunt, 80 per ct. decayed, 20 per ct. sound. The condition of some of these fruits is shown in Plate VI.

These results indicate that the development of the brown rot in peaches is practically checked while the fruit is in commercial cold storage, even though the fungus can enter the fruit through a break

in the epidermis. Peaches with a sound epidermis rolled in spores of the brown rot fungus did not develop the decay while in cold storage.

III. SULPHUR FUMIGATION TO DESTROY APPLE ROT FUNGI.

Experiments have been made to determine if it is possible by fumigation to destroy the spores of the various species of fungi that cause the decay of apples. If this were practicable it might be desirable to do so at the time the fruit storage house is being cleaned in preparation for the new crop. Especially would this be the case in an ordinary storage room where fruit is often allowed to decay and remain for some time.

The method of conducting these experiments was to first inoculate a quantity of apples with pure cultures of the various species of fungi. When the decay had developed in these fruits and the fungus was fruiting freely, cultures would be made by transferring some of the fungus to a sterile sugar beet plug, thus determining whether it was in an active condition. The fruits would then be placed in a tight room and different amounts of sulphur burned. Upon opening the room, usually a day later, cultures would again be made from the apples, thus determining whether the fungus was active or had been destroyed by the fumigation. Experiments were also made by blowing the spores of *Penicillium glaucum* (blue mold) in the air and then fumigating and determining if this destroyed the spores.

The apples used had been artificially inoculated with the following species of fungi which were fruiting freely on decayed areas: *Glomerella rufomaculans* (bitter rot), *Sphæropsis malorum* (black rot), *Penicillium glaucum* (blue mold), *Sclerotinia fructigena* (brown rot), *Cephalothecium roseum* (pink rot) and *Rhizopus* sp.

Before the fumigation, cultures were made of these fungi by transferring some of the spores to sterile sugar beet plugs in test tubes. When this was done the apples were placed in a tight room 8x9x10 feet, equal to 720 cubic feet. Four ounces of flowers of sulphur was placed in a dish and burned.

The room was kept closed for about 24 hours. When opened, cultures were again made in the same way as before, thus determining whether the spores had been destroyed by the fumigation.

The results indicated that all but the spores of *Penicillium glaucum* (blue mold) were destroyed. These were growing vigorously.

Repetitions of this experiment were made, using ½, 1, 1½ and 2 pounds of sulphur. One and one-half pounds of sulphur burned in a tight room which was kept tightly closed for about 24 hours gave fairly satisfactory results, but 2 pounds of sulphur gave entirely satisfactory results.

In this experiment there were used a large number of apples, which had been artificially inoculated and were producing an abundance of spores of the fungus.

After transfer cultures were made from all of these apples they were placed in a room which was made as tight as possible and the fumigation was done as follows: A large pan placed on the floor in the center of the room was filled with a quart or more of water, two bricks were set edgewise in this pan and on them rested a small tin pan which contained the 2 pounds of sulphur. This was easily ignited in the place where a teaspoonful of alcohol had been poured. The arrangement of the sulphur over water was done to eliminate any danger there might be from fire.

The room was closed immediately after the sulphur was ignited. About 24 hours later it was opened. Cultures were again made from all the apples. After a reasonable time was allowed for their growth they were all examined. Those made before fumigation were growing vigorously while those made after the fumigation had not grown at all. They were all kept under observation for some time, but no growth developed in any cultures made after fumigation.

The experiments to destroy the spores of *Penicillium glaucum* (blue mold) in the air were made by fumigating with 1 and 1½ pounds of sulphur to 720 cubic feet of space. The results with 1 pound indicated that it was insufficient, but 1½ pounds was used with good results.

The method was to secure a quantity of apples that were well covered with the spores of *Penicillium glaucum* (blue mold), part of them being placed on shelves in the room where the fumigation was done, the others set on a plate, and by vigorous fanning the spores were blown all about the room. One-half hour later 12 petri dishes containing sterile potato agar were placed on the floor of the room and their covers removed for exactly 3 minutes. During this time the operator remained in the room so as not to cause any unnecessary air currents by opening the door to go out.

The fumigation was then done in the way previously described. The room was kept closed for about 24 hours. When opened the

apples that were left in were set on a plate and the spores on them blown about the room. One-half hour later 12 petri dishes of sterile potato agar were exposed for 3 minutes in the same way as was done before fumigation.

A few days later an examination was made of all the plates. Those exposed before fumigation were completely filled with colonies of the blue mold. In the 12 plates exposed after fumigation most of them were entirely sterile and in the others there were only a few scattered colonies, which very evidently came as a result of contamination. See Plate VII.

The results of these experiments indicate that the spores of the fungi that cause the most common decays of apples, whether on the decayed fruit or floating in the air, can be destroyed by sulphur fumes, using about 1 ounce of sulphur to 25 cubic feet of space.

IV. APPLE INJURY BY SULPHUR FUMIGATION.

In March, 1905, a box of injured Esopus Spitzenburg apples was received at this Station with a request to diagnose the trouble, if possible. The apples were grown and packed in the State of Washington and shipped to New York where they were placed in cold storage. Upon being removed, some of the boxes of fruit showed the trouble while others from the same car were sound.

The fruit was of the first grade and each apple wrapped in paper. The financial loss was important, as a considerable amount of high priced fruit had been ruined from a commercial standpoint.

Scattered irregularly over the surface of each apple were conspicuous spots of various sizes where the epidermis was dead, discolored and slightly sunken. Each spot was nearly circular, though on some apples the adjacent spots had coalesced, forming a large affected area of irregular shape. Beneath each spot to the depth of a few millimeters the flesh was dead, shrunken and dry, appearing as though affected with a dry rot. See Plate VIII, fig. 1. There was no disagreeable odor or taste to the dead flesh or epidermis.

In the center of each of the smaller spots, and scattered over the larger affected areas, were small bodies resembling the pycnidia of a fungus, but examination showed them to be only the normal lenticels of the apples. Failure to find either fungi or bacteria as a cause of the injury led to the belief that some treatment of the fruit, such as fumigation, might be the cause. Sulphur, being commonly used for fumigation, was experimented with to note the effect of the fumes upon ripe apples. Fruits of different varieties,

including Esopus Spitzenburg, were placed in a bell jar which was then filled with sulphur fumes. After five minutes the fruit was removed and found to have developed numerous spots that were in every way identical with those on the apples received for examination. Plate VIII, fig. 2.

The experiment was repeated many times with wet and dry fruits, but the characteristic spots were always produced, though more conspicuous on red apples. The spots continued to enlarge for some time after the fruits were removed from the fumes.

The presence of a lenticel in the center of each spot would indicate that the sulplus dioxid passes into the fruit at this point and causes the bleaching of the tissue. A similar effect was produced when an artificial break in the epidermis was made. A lenticel makes a strong color contrast with the bleached epidermis, thus giving it the appearance of a pycnidium. Hydrocyanic acid gas was also tried but it did not injure the fruits, though a strong application was made for a good length of time.

These were the only two substances used; it is possible that other chemicals would produce a similar injury.

Why there should ever have been a desire to fumigate the fruit with anything is not clear. Where it was done and by whom could not be determined. It was first class fruit in every respect and certainly could not have been improved by any known treatment. It is possible that it was done by mistake when a car or store house was being fumigated.

The incident is valuable in bringing out the danger of fumigating fruit with sulphur, even though these apples may have been injured in some other way.

V. ENLARGEMENT OF APPLE SCAB SPOTS UNDER COVERING OF BORDEAUX MIXTURE.

The question often arises, will the development of a scab spot, *Venturia inæqualis*, upon an apple be checked if it is thoroughly covered with bordeaux mixture? Opinions upon this subject seem to have differed. Fairchild[1] states that the scab spot will grow

[1] Fairchild, D. G. Bordeaux mixture as a fungicide. U. S. Dept. of Agr., Div. of V. P., Bul. 6, p. 43.

beneath a layer of bordeaux mixture. Craig[2] states " that it is true that a scab spot will cease to enlarge if thoroughly covered with bordeaux mixture " and Warren[3] reports that the spot will continue to grow though covered with spray.

These reports appear to have been based upon general observations. Growers frequently want to know definitely about the matter as it has an important bearing upon the advisability of a late summer spraying in seasons when scab is especially severe. That information based upon experimental data might be secured, the following tests were undertaken:

On August 1, a number of apples showing well defined scab spots were found upon a Carolina June tree. They were conspicuously marked and the scab spot or spots to be under observation were numbered by marking upon the fruit with water proof ink and then making careful measurements of the spots. Part of the apples were thoroughly sprayed with bordeaux mixture, the others being reserved for checks. The bordeaux was the 5-5-50 formula and applied very thoroughly especially on the scab spots.

Frequent examinations were made of these apples and measurements and notes taken. In all but one case the spots that were covered with the bordeaux mixture continued to enlarge, as did all of the spots that were marked for checks.

Similar tests were made on August 3 with Rhode Island *Greening* and Fall Pippin. On August 6 with the same varieties and on August 30 with Rhode Island *Greenings*. In every one of these tests all of the scab spots enlarged after they had been covered with a thick coating of bordeaux mixture.

These results are what would be expected, as it is known that the scab fungus grows in the fruit beneath a thin outer layer known as the epidermis. See Plate IX, fig. 2. The margins or growing portion of the scab spot is then protected and beyond the reach of the action of the bordeaux mixture.

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[2] Craig, John, and Van. Hook, J. M. Pink rot an attendant of apple scab. Cornell Sta. Bul. 209, p. 167.

[3] Warren, G. F. An apple orchard survey of Wayne County, New York. Cornell Sta. Bul. 226, p. 339.

THE SPOROTRICHUM BUD-ROT OF CARNATIONS AND THE SILVER TOP OF JUNE GRASS.*

F. C. STEWART AND H. E. HODGKISS.

SUMMARY.

The carnation bud-rot herein described is identical with the disease discussed by Heald and Wolcott in Nebraska Experiment Station Bulletin No. 103. It is known to occur in several greenhouses in New York, Illinois and Nebraska, but probably it is not of great economic importance.

Silver top is a widespread grass trouble well known to entomologists, but not thoroughly understood. The flower panicles wither before they have become fully expanded. In New York, June grass (*Poa pratensis*) is very generally affected with silver top.

Carnations affected with bud-rot are invariably infested with a certain fungus almost constantly associated with a particular species of mite. The same fungus and mite are frequently found similarly associated on June grass culms affected with silver top. It has been proven that the fungus, by itself, is capable of producing bud-rot of carnations. The relation of the mite to the carnation disease is not entirely clear. Probably it acts as a carrier of the fungus. The relation of the fungus and mite to the silver top of grass has not been investigated.

Although the fungus of carnation bud-rot and the fungus on June grass have received different names (the former *Sporotrichum anthophilum* Pk. and the latter, *Sporotrichum poæ* Pk.), laboratory studies and inoculation experiments show them to be one and the same species. *S. poæ*, being the older of the two names, must be given precedence.

The mite is the same as the one to which Wolcott gave the name *Pediculoides dianthophilus*; but it has been identified positively as *Pediculopsis graminum* Reut. which, according to Reuter, is the chief agent in the production of silver top of grasses in Finland.

*A reprint of Technical Bulletin No. 7.

PLATE X.—CARNATION BUDS AFFECTED WITH BUD-ROT.
Left, opened bud showing diseased area; right, diseased bud with mites.

BUD-ROT OF CARNATIONS.[1]

In November, 1905, a Long Island[2] florist sent to the Experiment Station some diseased buds of the carnation, *Dianthus caryophyllus* L., accompanied by a request for information concerning the cause of the disease and its control. The sender stated that he had been growing carnations extensively for thirteen years and had never before had any trouble of this kind. Six to eight per ct. of the buds were ruined. The plants bearing the diseased buds were thrifty and belonged chiefly to the varieties Lawson, Bradt and Enchantress. The disease reappeared in the autumn of 1906 and again in 1907 with about the same severity as in 1905. Each year the diseased buds have been most plentiful between October 1 and January 1, the trouble disappearing almost completely after about the middle of January.

The disease is characterized as follows: Outwardly, the affected buds usually appear like normal buds partially opened, but upon the interior they are brown, decayed and generally moldy. Sometimes the decayed tissue shows at the center of the bloom on top and in the advanced stages it may be seen on the sides between the calyx teeth. The stamens, styles and lower portions of the petals are attacked first. Frequently, the pistil, also, is affected. The tips of the petals are the last to be attacked and it often happens that petals badly decayed in their lower parts covered by the calyx appear quite normal at their exposed tips. When small, unopened buds are killed by the disease the calyx also frequently becomes affected, but in large buds the calyx usually remains green and normal although the other parts may be a mass of decay.

The brown decayed tissue on the interior of the diseased buds is thoroughly permeated by the mycelium of a fungus, a species of Sporotrichum, usually plainly visible as a loose, cottony white mold.

The first lot of specimens from Long Island contained eight partially-opened buds every one of which showed an abundance of the Sporotrichum sporulating freely. No other fungus was present. In every case the Sporotrichum was apparently in pure culture. However, three of the buds contained, also, a few glistening,

[1] By F. C. Stewart.

[2] The exact location of the infested greenhouses is withheld out of deference to the wishes of the owner who desires to avoid publicity and possible injury to his business therefrom.

whitish, ovoid bodies about the size of red clover seeds. These were supposed to be the eggs of some insect, but no larvæ were seen and there was no mutilation of the tissues by insects. The evidence plainly pointed to the Sporotrichum as the cause of the decay. This aroused the writer's interest since there are few plant parasites among the numerous species of Sporotrichum[3] although the genus contains some important insect parasites the most notable one being *S. globuliferum*, a destructive parasite of the chinch-bug and several other insects.[4] Specimens of the carnation Sporotrichum were sent to Prof. Peck who pronounced it a new species and named it *Sporotrichum anthophilum*.[5]

At our request, the Long Island florist forwarded (Nov. 11, 1905) another package of specimens containing 24 diseased buds very similar to those sent previously. In every one of these there was an abundance of Sporotrichum mycelium and some spores while in the majority of them multitudes of spores were found. No other fungus was seen, but most of the specimens contained a few of the supposed insect eggs previously mentioned. An unsuccessful attempt was made to hatch some of them. Pure cultures of the Sporotrichum were obtained. It was found to grow readily and sporulate freely on potato agar and on sterilized plugs of sugar beet. On the latter medium a bright red color is produced wherever the hyphæ come in contact with the beet.

December 8, 1906, ten more affected buds were received from

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[3] The following species of Sporotrichum are probably parasitic on plants: *S. arabicum* Massee on the inflorescence of *Phœnix dactylifera; S. biparasiticum* Bubák on branches of *Coronilla emeri; S. canescens* Speg. on the hyphæ of *Cercospora hydropiperis; S. hellebori* Oud. on the leaves of *Helleborus fœtidus;* and *S. parasiticum* Peck on the black knot fungus, *Plowrightia morbosa* (Peck, C. H., N. Y. State Mus. Nat. Hist. Rpt., **45**: 82) and on sclerotia of the grape black rot fungus (Prunet, A. Abstract in *Exp. Sta. Rec.*, **11**: 357).

[4] For experiments on the destruction of chinch-bugs by means of *Sporotrichum globuliferum* see the following:

Snow, F. H. Contagious diseases of the chinch-bug. Univ. of Kansas Exp. Sta. Ann. Rpts. of the Director 1–5. 1891–5.

Forbes, S. A. On contagious disease in the chinch-bug (*Blissus leucopterus* Say). Nineteenth report of the State Entomologist on the noxious and beneficial insects of the State of Illinois. Eighth report of S. A. Forbes for the years 1893 and 1894, pp. 16–176. 1895. Contains an extensive bibliography with short abstracts.

[5] Peck, C. H. Report of the State Botanist 1905. N. Y. State Mus., Bul. 105: 28. 1906.

Long Island. They presented the same symptoms as those studied in 1905. One was brown and dry, but the other nine showed apparently healthy petals on the outside while within they were all more or less decayed. In all ten buds the decayed tissue was overgrown with Sporotrichum which was fruiting profusely. No other fungus was found in any of the specimens, but the whitish, ovid, egg-like bodies were again in evidence.

At this point in the investigation Mr. H. E. Hodgkiss, Assistant Entomologist, discovered that the supposed insect eggs were in reality *mites* having enormously distended abdomens. It was decided that he should make a study of the curious creatures and their relation to the carnation disease. The results of his investigation appear on pages 159, 165.

A fourth lot of specimens received from Long Island on December 19, 1906, was divided between Mr. Hodgkiss and the writer. The latter's share consisted of 14 buds in the early stages of the disease. Every one was thoroughly infested with Sporotrichum. No other fungus was found.

A fifth lot of specimens, received August 9, 1907, differed from any previously seen in that they were quite small buds which had died and become brown long before reaching the blooming stage. On the interior the dead buds were moldy with Sporotrichum. They came from plants which had been transplanted into the greenhouse about July 1.

Still a sixth lot of specimens was received October 2, 1907. It contained 18 buds most of which would readily pass for healthy buds about one-half open. Yet, within, every one was badly diseased and overgrown with Sporotrichum. Mites, also, were present.

Besides the establishment above mentioned, at least one other Long Island greenhouse is known to be infested with the Sporotrichum bud-rot. Several specimens of the disease were found here in August, 1907, and the writer has in his possession notes and drawings showing that he saw the same disease in this greenhouse in January, 1901. At three different times during 1907 (February, August and November) a large carnation establishment at Geneva was searched for evidence of the Sporotrichum disease. Each time traces of it were found, and curiously enough the same peculiar mite was associated with it. A circular letter of inquiry sent out by the Station in December, 1907, to about sixty New York florists elicited twenty-five replies. Five florists reported having had more

or less trouble with carnation bud-rot, but only one sent specimens of the Sporotrichum disease. These came from a greenhouse in the middle Hudson Valley. The diseased buds showed the same Sporotrichum and mites as those previously examined. The owner stated that the disease was not destructive.

The disease is known to occur also in Nebraska and Illinois. Dr. F. D. Heald, Botanist of the Nebraska Station, sent us specimens from Nebraska showing both Sporotrichum and mites. More will be said about these specimens later. In Illinois it is prevalent in greenhouses about Chicago and Bloomington. For our knowledge of the disease in Illinois we are indebted to Mr. J. J. Davis, Field Entomologist for Northern Illinois. Mr. Davis discovered the carnation bud-rot in October, 1907, and at once began a study of it. Later, finding that the writers had the subject under investigation, Mr. Davis kindly sent us his notes for use in this bulletin. They are as follows:

"I first found rotting carnation buds containing mites on October 24, 1907, in greenhouses at Chicago. Mr. A. C. Beal has since found this same injury in houses in Bloomington. No other carnation houses in Illinois (excepting two at Centralia, referred to later) have been inspected, but as these two localities are widely separated it is quite probable that it is generally distributed over the State. It was quite general in the houses at Chicago and sufficiently abundant in some houses to cause alarm among growers.

"The rot was most abundant during the latter part of October when I first observed it. In the house which was worst infested the rotted buds were picked at that time. This house was again visited in December and very few decayed buds were found. In other houses, only occasional rotted buds were found on this latter date, where they had been rather common a month before. Here, likewise, the diseased buds had been picked since the first observation. Upon a third observation made January 21, 1908, not a single infested bud could be found.

"The white varieties such as Lawson and Perfection seemed to be the worst attacked. The pink and light red varieties were only slightly affected, while among the dark red varieties I found no rotting buds.

"From my observations it seems evident that the mite is the direct cause of the fungus attack, for in all cases the rotting begins in the center of the bud and were it a fact that the spores are disseminated by wind or water we should expect to find the rot begin-

ning from the outside, at least in some cases. Also, mites were found in all buds with the characteristic rot. Usually, there were but two or three mites in a single bud, sometimes only one, while occasionally as many as ten or more were found.

" Following an initial determination by Mr. Hodgkiss, Mr. H. E. Ewing of the University of Illinois made a careful examination of the mites in the diseased buds and found that, except in one bud, they were all *Pediculopsis graminum* Reuter. In the bud excepted, the mites were of the species *Tyroglyphus lintneri* Osborn. This bud had been left in a covered lamp chimney used as a breeding cage and when examined several days later over 100 mites and 50 or more eggs of the same were found in the bud, all of which proved to be of the last mentioned species. Whether they were the original inhabitants that carried the fungus spores to the bud or whether they got into the rotting bud accidentally could not be determined, but in any case they are not the species generally associated with the bud-rot. The fungus which is associated with these mites and is the cause of the rot was determined by Mr. J. T. Barrett of the University of Illinois as a species of Sporotrichum.

" Flowers attacked by this fungus are not only decayed in the center but are also characteristically deformed, sometimes being more or less lop-sided and in every case with the inner petals closed at the top as if all of the tips of the petals were fastened together in the center.

" So far as I know, all of the carnation growers around Chicago use sod soil and renew it every year. At two houses in Centralia where examinations were made the bud-rot was not found and upon inquiry it was learned that sod soil had not been used."

Through the kindness of Mr. Davis we have had an opportunity to examine two lots of diseased buds from Chicago. The first lot consisted of three buds all of which contained the usual mites and were abundantly infested with Sporotrichum. The second lot contained 13 buds. Three of these proved to be normal. The other ten presented the usual symptoms of bud-rot. Nine of the latter contained an abundance of Sporotrichum. Some mites, also, were present. Both the Sporotrichum and the mites were identically like those found in the New York and Nebraska specimens. Eight of the nine buds contained no other fungus besides the Sporotrichum, but the ninth showed also an undetermined hyphomycetous fungus with small, elliptical-oblong, non-septate, hyaline spores. The remaining bud of this lot was peculiar. In a general way it showed

the symptoms of Sporotrichum bud-rot, the exposed petal tips being normal while the interior parts were decayed and moldy. The strange thing about it was that the decayed petal claws were decidedly reddish although the blades were white. Neither Sporotrichum nor mites were found in this bud. Instead, there was an abundant growth of a species of Fusarium.

It is noteworthy that in three states — New York, Illinois and Nebraska — Lawson is the variety most affected. This variety appears to be particularly susceptible. Two other varieties found to be especially susceptible in New York are Enchantress and Bradt. It is interesting to note the relationship of these three susceptible varieties. Enchantress is a seedling of Bradt crossed with Lawson.[6] It was originated by Peter Fisher, Ellis, Mass., in 1899.

Now that we are able to differentiate it from other bud troubles of the carnation it seems probable that the Sporotrichum disease will be found in a rather common but not an especially important one. In floricultural literature there are numerous references to bud troubles of the carnation. Sometimes the description given answers, in a general way, for the disease under consideration. For example, a correspondent of the *American Florist*[7] writes as follows: "The buds form and expand but never open full, only about half, and then dry up and wilt." Another correspondent of the same journal[8] writes: "They [the plants] make a clean healthy growth and produce good stems but fully three-fifths of the flowers go to sleep when about half developed." It is quite possible that these were cases of Sporotrichum bud-rot.

The "abnormal carnation flowers" described by Arthur[9] is an entirely different trouble as is also the Botrytis disease mentioned by Atkinson.[10] The hard dry "petrified buds" described by Kinney[11] are likewise to be ascribed to other causes, probably. However, the Sporotrichum disease sometimes takes that form.

Owing to the fact that there are several different bud troubles of the carnation which might be appropriately called bud-rot this

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[6] Ward, Charles Willis. The American carnation: How to grow it. p. 266. A. T. De La Mare Printing and Publishing Co., New York. 1903.

[7] *Amer. Florist,* 12: 514. 2 Ja. 1897.

[8] *Amer. Florist,* 13: 819. 26 F. 1898.

[9] Arthur, J. C. Abnormal carnation flowers. *Florists' Ex.,* 8: 167. Illus. on p. 197.

[10] Atkinson, Geo. F. Carnation diseases. *Amer. Florist,* 8: 728. 23 F. 1893.

[11] Kinney, L. F. R. I. Sta. Rpt. for 1896: 209–210.

Plate XI.— Silver Top of June Grass (*Poa pratensis* L.).

1 Affected panicle, withered before fully expanded. 2, Healthy panicle expanded normally. 3, Lower parts of affected panicles with sheath removed to show withering of culm just above uppermost node.

name is not sufficiently distinctive. Hence, we propose the name Sporotrichum bud-rot.

Up to the time of the discovery of the true nature of the bodies supposed to be insect eggs it had not occurred to us that our disease might be the same as that described by Heald[12] under the caption, " Bud-rot, Fusarium and a Mite." But it was now observed that our mite agreed with Heald's description of the mite found by him. At our request, Dr. Heald kindly sent us (April, 1907) four carnation blooms affected with this bud-rot. Three of these blooms were identically like those from Long Island — they showed an abundance of Sporotrichum free from admixture with any other fungus and there were also present mites which were pronounced by Mr. Hodgkiss to be the same as those found in the Long Island specimens. The fourth bloom, also, contained an abundance of Sporotrichum and some mites, but in addition thereto a considerable number of pluri-septate, hyaline, Fusarium-like spores. By means of dilution cutures in potato agar, an attempt was made to isolate both the Sporotrichum and the Fusarium. Pure cultures of the former were obtained easily, but the Fusarium was elusive. A further discussion of this subject appears on page 155.

SILVER TOP OF JUNE GRASS.[13]

June grass, *Poa pratensis* L., is a very common grass in New York particularly along the highways and railroads. When it begins to " head " in the latter part of May a large percentage of the panicles wither before they become fully expanded. Affected panicles are conspicuous because of their light color. One accustomed to observe such things can scarcely fail to notice the trouble when it is at its height during the last week in May and the first half of June. At that time it is abundant all over the State. A very little investigation of the affected plants suffices to show that the seat of the trouble is, in most cases, just above the uppermost node. Here, the tender portion of the culm is badly shriveled (but not noticeably gnawed) over a section 5 to 10 millimeters in length. This may be readily observed by gently pulling one of the withered panicles from its sheath. (See Plate XI, fig. 3.) Sometimes the injury instead of being at the uppermost node is at the next one

[12] Heald, F. D. Bud-rot, Fusarium and a mite. Nebr. Sta. Rpt., 19: 55. 1906. See also *Science*, N. S., 23: 620. 20 Ap. 1906.

[13] By F. C. Stewart.

below. In such cases the leaf and sheath springing from the uppermost node are dead, dry and light colored like the panicle.

This trouble of June grass is well known to entomologists.[14] In America it is often called "silver top"; and the cause of it is believed to be some sucking insect, *Anaphothrips striata* Osb. being the particular species usually held responsible for it. However, some writers express the opinion that it may be brought about by any one of several species. Reuter,[15] who made an exhaustive investigation of it in Finland, gave it the German name Weissährigkeit and attributed the greater part of it to certain species of mites. Hinds[16] gives a list of 32 species of grasses which are more or less subject to silver top in Massachusetts. In New York, June grass is the species most conspicuously affected; although the

[14] Some of the principal American articles on silver top and its causes are the following:

Cary, Lewis R. The grass thrips (*Anaphothrips striata* Osborn). Me. Sta. Bul. 83. 1902.

Comstock, J. H. Notes on entomology: A syllabus of a course of lectures delivered at the Cornell University, p. 120. Ithaca, N. Y. 1875.

————. The grass-eating thrips. *Amer. Nat.*, **22**: 260—261. 1888.

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Fernald, H. T. and Hinds, W. E. The grass thrips, *Anaphothrips striata* (Osb.). Hatch Exp. Sta. of the Mass. Ag. Coll., Bul. 67. 1900.

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Hinds, W. E. The grass thrips. Mass. Ag. Coll. Rpt. **37**: 83—105. 1900. Contains bibliography.

Lintner, J. A. An unknown grass pest. N. Y. State Mus. Nat. Hist. Rpt. **40**: 96–98. 1887.

————. N. Y. State Mus. Nat. Hist. Rpt. **42**: 153, 304. 1889.

Osborn, H. Silver top in grass and the insects which may produce it. *Canad. Ent.*, **23**: 93–96. 1891.

Webster, F. M. Notes on some species of insects which affect the upper portion of the stems of some grasses. *Insect Life*, **1**: 372–374. 1889.

[15] Reuter, Enzio. Ueber die Weissährigkeit der Wiesengräser in Finland. Ein Beitrag zur Kenntnis ihrer Ursachen. *Acta Soc. pro Fauna et Flora Fennica*, **19**: No. 1, pp. 1–136. Helsingfors, 1900. Contains an extensive bibliography. (Abstract in *Ztschr. Pflanzenkrank.*, **11**: 250–253.)

[16] Hinds. loc. cit., p. 94.

trouble is sometimes quite common with timothy, and several other grasses show it occasionally.

While studying this trouble of June grass in 1902 the writer discovered that in specimens collected on the Station grounds the shriveled portion of the affected culms was almost always covered with a copious growth of a delicate white fungus belonging to the genus Sporotrichum. Frequently, there was associated with the Sporotrichum a species of mite. The mite was not identified until five years later (see page 160), but specimens of the Sporotrichum were sent to Prof. Peck who pronounced it an undescribed species and gave it the name *Sporotrichum poæ*.[17]

For a time it was suspected that the Sporotrichum might be one of the causes of silver top, but this idea was subsequently abandoned when it was found that in the majority of cases the affected culms were quite free from Sporotrichum or other fungus. However, both the Sporotrichum and the mite reappeared to a limited extent about Geneva in 1903, 1905, 1907 and 1908; also at Interlaken, N. Y., in 1907. In one instance the Sporotrichum and associated mite were found on timothy, *Phleum pratense* L., affected with silver top.

In reviewing the literature of silver top the writer has found but two references to fungi in connection with the trouble.[18] One of these is in an article by Osborn[19] whose studies were made in Iowa. He says: "In a very few cases I have seen evidence of fungi present in the shriveled base of the withered node, but so very few and in such cases so evidently a consequence of the injury that I do not think it can be credited with any of the damage." Prof. Osborn writes us that the fungi were not identified. The other reference is by Reuter[20] whose studies were made in Finland. He says: "Nicht selten treten in regnerischen Zeiten an der morschen Partie Schimmelpilze auf, welche mitunter als Ursachen der Erkrankung der betreffende Pflanze angesehen worden sind. Die fraglichen Pilze finden sich indessen stets nur sekundär, an dem schon vorher durch tierische Angriffe beschadigten und dadurch morsch gewordenen

[17] Peck, C. H. Report of the State Botanist. 1902. N. Y. State Mus. Bul. 67: 29. 1903.

[18] This excludes the oat disease described by Kirchner (*Ztschr. Pflanzenkrank.*, 14: 18. 1904.) in which the diseased culms were infested with a species of Sporotrichum in association with the mite *Tarsonemus spirifex* Marchal, the latter supposed to be the cause of the trouble.

[19] Osborn, loc. cit., p. 94.

[20] Reuter, loc. cit., p. 52.

Teil des Halmes ein." No clue to the identity of the fungi is given.

The above discussion of silver top is brought into this article on carnation bud-rot not because our investigation throws any new light on the cause of silver top, but for the reason that the Sporotrichum and the mite found in connection with it prove to be identical with the Sporotrichum and mite of carnation bud-rot.

RELATIONSHIP OF *SPOROTRICHUM POÆ*, *S. ANTHOPHILUM* AND HEALD'S *FUSARIUM*.[21]

As the investigation advanced it gradually became evident that *Sporotrichum poæ* Pk., *Sporotrichum anthophilum* Pk. and Heald's bud-rot Fusarium are one and the same species. In the first place, a comparison of Peck's descriptions of his two species of Sporotrichum shows them to be strikingly alike except as to the host plant. *Sporotrichum poæ* is described as follows: "Hyphæ slender, .00008—.00012 of an inch thick, procumbent, branched, slightly interwoven, white; spores colorless, subglobose, .00016—.00032 of an inch [4 to 8 μ] broad. Sheaths and culms of Kentucky blue grass, *Poa pratensis*."

Sporotrichum anthophilum is described as follows: "Hyphæ creeping, interwoven, branched, continuous or sparingly septate, variable in thickness, .00008—.00024 of an inch in diameter, hyaline, forming a loose cottony stratum; spores globose or broadly ovate, .00016—.0003 of an inch long, borne at the tips of short branchlets which are usually narrowed toward the apex and pointed. Parasitic on the filaments and petals of carnation pinks destroying their vitality and spoiling the flowers."

It will be observed that neither description contains any reference to septate spores although spores distinctly once-septate like those shown in Plate XIII, fig. 3, occur almost constantly both in the carnation fungus and in the June grass fungus. Without having made any attempt at an accurate determination it is estimated roughly that, in carnation buds, the usual proportion is about one septate spore to 100 or 200 non-septate spores. Occasionally, they may be as frequent as one to twenty-five and occasionally so rare that a long search is required to find one. As a rule they are easily recognized, being somewhat larger than the ordinary spores and more or less pear-shaped, whereas the ordinary spores are well described as "globose or broadly ovate." That these large, pear-shaped, two-

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[21] By F. C. Stewart.

celled spores really belong to the Sporotrichum is proven by the fact that they have been observed repeatedly in cultures known to be pure. They have been observed in pure cultures of *Sporotrichum poæ* and *S. anthophilum* on acidulated potato agar, plugs of sugar beet and various other media. The production of these unusual spores is to be regarded as strong evidence that the two fungi belong to the same species. In none of the 142 species of Sporotrichum described in Saccardo's Sylloge Fungorum is there any mention of septate spores.

In addition to the spores just mentioned two-septate and even three-septate spores are occasionally found in the carnation fungus and also in the June grass fungus in pure cultures as well as in nature. These are quite variable in size and shape. They are almost always longer than the once-septate spores and either straight or slightly curved. Sometimes they are plainly septate and quite Fusarium-like as shown in Plate XIII, fig. 4. In other cases the septa are indistinct and it may be uncertain whether they are spores or only spore-bearing branches of the hyphæ which have become detached.

It appears that it was the presence of these pluri-septate spores which caused Dr. Heald to refer his carnation bud-rot fungus to the genus Fusarium. It has already been stated that the four carnation buds sent by Dr. Heald as representative of his disease all showed an abundance of Sporotrichum with multitudes of the typical globose or broadly ovate spores; but one of the buds contained, also, a considerable number of the Fusarium-like spores. This particular bud showed a larger proportion of such spores than we have ever seen in any of the New York specimens; yet they were few as compared with the multitudes of typical Sporotrichum spores. So far as could be determined the mycelium was all of one kind and attempts to isolate the Fusarium by the dilution method failed notwithstanding the medium used was acidulated potato agar on which most Fusaria grow readily. The pure cultures obtained produced about the same proportion of once-septate and pluri-septate spores as the cultures obtained from New York carnations and June grass.

Grown in pure cultures under parallel conditions the three fungi (*S. anthophilum, S. poæ* and Heald's figures) look and behave identically alike. On acidulated potato agar and on plugs of sugar beet at room temperature they grow readily producing a copious white mycelium and sporulating freely in from four to seven days. On

some kinds of media all three produce almost constantly a bright red color where the mycelium comes in contact with the substratum. This is conspicuous. It has been observed in cultures on sterilized sugar beet, turnip, potato, wheat bread, cabbage and apple. The red color does not appear in cultures on potato agar, alfalfa agar, alfalfa stems, cosmos stems or gelatin.

The writer is in doubt as to the value of this red color as a diagnostic character. Such color production is by no means rare in some other genera, notably in Fusarium, but how common it is among the species of Sporotrichum we do not know and have been unable to learn much about it from the literature. We have had opportunity to cultivate but two other (undetermined) species[22] of Sporotrichum neither of which showed any tendency to produce the red color.

Pettit,[23] who grew *Sporotrichum globuliferum* Speg. on sterilized potato observed a purple tinge in the near vicinity of the fungus colonies; and Forbes[24] states that in some experiments made by him cabbage worms inoculated with *Sporotrichum globuliferum* were frequently, but not invariably, turned to a dull red color by the fungus.

In the closely related genus Isaria the production of red color in artificial cultures is said to be common. Pettit[25] found that potato and gelatin are colored purple by *Isaria densa* (Lk.) Fries.; that larvæ and pupæ of the cabbage worm, *Pieris rapæ,* inoculated with *Isaria vexans* Pettit become "a deep vinaceous purple;" and *Isaria* sp. indet. produced red or purple color on potato. Giard[26] states that a certain rosy color is very characteristic of *Isaria densa* cultivated on artificial media; also, that similar color appears more or less distinctly in cultures of other Isariæ and notably in cultures of the silk worm muscardine, *Botrytis bassiana* Bals.

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[22] For one of these we are under obligations to Prof. H. H. Whetzel of Cornell University and for the other to Dr. C. W. Edgerton of the Louisiana Experiment Station.

[23] Pettit, R. H. Studies in artificial cultures of entomogenous fungi. Cornell Sta. Bul. 97: 364. 1895.

[24] Forbes, S. A. Experiments with the muscardine disease of the chinch-bug, etc. Ill. Sta. Bul. 38: 33, 43, 44. 1895.

[25] Pettit, loc. cit., pp. 360, 367, 369.

[26] Giard, A. *L'Isaria densa* (Link) Fries, champignon parasite du hanneton commun (*Melonotha vulgaris* L.). *Bul. Sci. France et Belg.* 24: 1893. An extended review of this paper is given by V. L. Kellogg, Univ. of Kans. Exp. Sta. Third Annual Report of the Director, pp. 227-239. 1894.

The cause of this red color and the conditions under which it is formed are not thoroughly understood. Apparently, the requisite conditions vary with different fungi. In the case of the carnation stem-rot Fusarium the writer has found that in order to secure bright colors it is necessary to grow the fungus at a rather high temperature. Erwin Smith has studied this problem in its relation to the melon-wilt fungus, *Neocosmospora vasinfecta* (Atk.) Erw. Sm. After recording the color of the mycelium of this fungus when grown on various culture media he says:[27] "My conclusions relative to the formation of color by the melon fungus are as follows:

"(a) On neutral or acid media in the presence of free oxygen and of starchy foods — e. g., potato, bread, rice, tapioca, wheat, hominy, cucumber agar, etc.— this fungus develops in the substratum a series of the most brilliant colors, which are then absorbed by the hyphæ. These hues include many shades of pink, red, purple and violet, and in some of the substrata — e. g., bread or boiled rice — are particularly brilliant, changing gradually from shades of purple and rose color into the deepest crimson (rose carthamine). This color is much brighter and purer than any I have been able to obtain with Went's *Monascus purpureus*. During the development of this pigment the substratum becomes intensely acid (mostly CO_2, but some lactic acid according to Mr. K. P. McElroy). If, however, alkaline substances (caustic lime, carbonate of soda, etc.) be added to the substratum in advance, so as to neutralize the acid or acids as fast as formed, no color is developed, the fungus remaining snow white, as in the vessels of the melon plant. If less alkali be added, the colors appear gradually after a time, which is longer or shorter according to the amount added.

"(b) The yellow and brown colors are formed in the presence of an alkali, but apparently not unless sugar is also present."

Later, Smith and Swingle[28] found that also incultures of the potato dry-rot fungus, *Fusarium oxysporum* Schlecht., there exists a somewhat similar relation between the acidity of the medium and the production of red color. Light, also, seemed to be a factor when the fungus was grown on certain media, while on other media it

[27] Smith, Erwin F. Wilt disease of cotton, watermelon and cowpea. U. S. Dept. Agr. Div. Veg. Phys. and Path. Bul. 17: 23. 1899.

[28] Smith, Erwin F. and Swingle, Deane B. The dry rot of potatoes due to *Fusarium oxysporum*. U. S. Dept. Agr. Bureau Plant Ind. Bul. 55: 34-49. 1904.

made no difference whether the cultures were grown in darkness or in sunlight.

Hedgcock,[29] in his studies on chromogenic fungi which discolor wood, also found the chemical reaction of the medium to be an important factor in color production. But it is noteworthy that with one species, *Penicillium aureum* Cda., the presence of an alkali *favored* the formation of red color instead of hindering it as was found by Smith and Swingle in the species studied by them.

Returning, now, to our own observations — the carnation Sporotrichum, the June grass Sporotrichum and Heald's bud-rot fungus all three produce the same red color in cultures. On some media, especially plugs of sugar beet, this color may be depended upon to appear under almost any condition of light, temperature, acidity or alkalinity not incompatible with growth. On sugar beet, the color is somewhat more brilliant in darkness than in diffused light, and on acid media than on alkaline, but the differences are not great. At 20° C. the time required for the appearance of the red color varies from three to seven days. It appears sooner on sugar beet than on potato, but ultimately it may become quite as brilliant on the latter as on the former. On the same medium and under apparently parallel conditions the color in different cultures varies considerably in shade. In occasional cultures no color ever appears. The three strains of Sporotrichum have been grown on various culture media and under various conditions for the purpose of finding cultural characters by means of which they might be separated, but the resulting variations in color, habit of growth, spore formation, etc., have been no greater than those commonly occurring between individual cultures of the same strain.

The association of all three fungi with the same species of mite is at least suggestive of unity and finally, all three are parasitic on carnation buds. Heald has proven the parasitism of his fungus and the writer has done the same for *Sporotrichum poæ* and *S. anthophilum*.

It having been proven that *Sporotrichum poæ* and *Sporotrichum anthophilum* are two names for one and the same fungus, the former name should be given preference since it is the older. However, it is by no means certain that the fungus has not been previously described under yet a different name.

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[29] Hedgcock, George Grant. Studies upon some chromogenic fungi which discolor wood. Mo. Bot. Gard., Rpt., 17: 59–117. 1906.

INOCULATION EXPERIMENTS WITH THE FUNGUS.[30]

Inoculation experiments with pure cultures of the Sporotrichum have given varying results. Thirteen different experiments were made, the total number of inoculated buds being 107 and the number of checks 18. Four of the inoculated buds and one of the checks were accidentally destroyed. None of the checks showed any browning of the tissue or other ill effects from the treatment they received. Of the 103 inoculated buds which were carried through to the end of the experiment 36 were ruined by the Sporotrichum, 21 others showed slight injury, while the remaining 46 were scarcely, if at all, affected by the inoculation. That is to say, only about 35 per ct. of the inoculations can be regarded as positively successful. The many failures show that the fungus is not an aggressive parasite or else the conditions surrounding the experiments were in some way decidedly unfavorable to the disease. The cultures used for inoculation were from three or four different sources and all isolated within six months of the time of using them. They were grown on plugs of sugar beet from 7 to 19 days and invariably examined before using to make sure that they were sporulating freely. In most cases, the inoculations were made through the side of the bud by the following method: By means of a sterile awl a small opening was made in the calyx. Through this opening a bit of the fungus from a pure culture was introduced into the interior of the bud in one of two ways: (1) A fragment of mycelium bearing spores was poked in with a strong platinum needle; or (2) by means of a pipette spore-laden water was forced in until drops of it exuded from the tip of the bud. In experiments in which the first method was used the check buds were simply punctured with the awl, but when the second method was used sterile water was forced through the punctures into the check buds. Several fully expanded blooms were inoculated with spore-laden water through a pipette inserted into the center of the bloom from the top. Some of the inoculations were made in the open greenhouse; others in a large glass inoculation chamber in which the air was saturated with moisture.

Most of the inoculations were made on Boston Market, a white variety. It may be that this variety is partially resistant to the

[30] By F. C. Stewart.

disease, which would account for the large percentage of failures. Later inoculations, made on Enchantress and Gov. Wolcott, were more successful. It is probable that in some of the experiments better results would have been obtained of the buds had not been cut so soon. It appears that from 10 to 15 days are required for the fungus to destroy the buds in typical fashion. Buds in all stages of development, including fully expanded blooms, were successfully inoculated, but the best results were obtained with small, unopened buds. It is also plain that an abundance of moisture in the air is favorable to the disease. Inoculated buds on plants kept in a moist chamber after inoculation were soon conspicuously overgrown with the Sporotrichum and ruined; whereas, in the open greenhouse, under conditions otherwise parallel, the progress of the disease was slow and uncertain. This is as would be expected.

Most of the inoculations were made with Sporotrichum isolated from carnations (*S. anthophilum*). Sporotrichum from June grass (*S. poæ*) was used in three experiments, Nos. 11, 12 and 13, as follows:

Experiment No. 11.—On Nov. 16, 1907, two buds (one showing color and the other of large size but unopened) of Gov. Wolcott were inoculated with a pure culture of Sporotrichum isolated from June grass July 5, 1907. The inoculations were made in the usual manner by forcing spore-laden water through a hole in the side of the calyx. (The Sporotrichum spores were already germinating, having been placed in the water 20 hours previously.) After inoculation the plants were kept in a moist chamber where the temperature was about 13° C. by night and 21° C. by day. There were no checks.

At the end of two weeks the buds were cut and examined. The more adanced one was now fully expanded. It was evident that the fungus had taken effect. The pistil and bases of the petals had been destroyed, but owing to the splitting of the calyx which permitted the petals to hang apart, the upper portions of the petals were unaffected. The other inoculated bud was half open. Viewed from the top, about half the petal tips appeared normal while the remainder were brown with decay. On the interior of the bud the petals were badly decayed and glued together, the tissues being thoroughly permeated with Sporotrichum hyphæ fruiting moderately but not forming a conspicuous mold. In this bud the petal bases were unaffected.

Experiment No. 12. —On Nov. 18, 1907, ten buds, (5 show-

ing color and 5 large but unopened) of the variety Boston Market were inoculated with Sporotrichum from June grass exactly as in Experiment No. 11 except that the spores were not so far advanced in germination, having been placed in water but six hours before the inoculations were made; and the plants instead of being placed in a moist chamber were left in the open greenhouse. At the same time, in the same manner and under exactly parallel conditions, ten other buds were inoculated with Sporotrichum from carnations. There were also five check buds (showing color) which were injected with sterile water.

At the end of 15 days all of the buds were cut and examined. Of the 5 buds showing color at the time of inoculation with June grass Sporotrichum, four had fully expanded and partly withered without evidence of injury from the fungus, but the fifth was only half open, badly decayed within and presenting a typical case of Sporotrichum bud-rot. Of the 5 unopened buds inoculated with June grass Sporotrichum, one had been destroyed by some animal, three were fully expanded and showing only slight injury while the fifth was completely ruined by Sporotrichum.

The inoculations with carnation Sporotrichum were more successful. The 5 buds showing color at time of inoculation gave negative results except that in three cases the pistil had been destroyed; but the 5 buds which were yet unopened at time of inoculation were now about half open, much decayed in the center, somewhat moldy and all good typical examples of Sporotrichum bud-rot.

The five check buds had expanded normally without any discoloration or other evidence of injury.

The details of Experiment No. 13 are given on page 158.

No mites have been found in any of the inoculated buds. It is possible that the mites in addition to serving as distributors of the fungus may assist the fungus in making its attack on the tissues.

There being no evidence that the fungus attacks anything but the buds no attempt has been made to inoculate it into any other part of the carnation plant.

Notwithstanding numerous failures, the 36 successful inoculations described above seem to prove conclusively that the Sporotrichum found in carnation buds affected with bud-rot is a parasite and the cause of the disease.

EXPLANATION OF PLATE XII.

A and B were two buds of the same age on the same carnation plant, variety Enchantress. When the buds were of the size of C and just beginning to open, B was inoculated with a pure culture of *Sporotrichum poæ* isolated from a diseased carnation bud two months previous. Inoculation was affected by forcing into the bud (through a hole made in the calyx) water containing spores of the fungus. A, used for a check, was similarly injected with sterile water. A bell jar was then placed over the plant. Twenty days later the two buds were cut and photographed, natural size. A was then a perfect bloom, while B was completely ruined. In the latter, all parts except the calyx were decayed and overgrown with a fine, white, cottony growth of the Sporotrichum which was sporulating freely.

Plate XII.— Inoculation Experiment (No. 13) on Carnation Buds.

(See opposite page.)

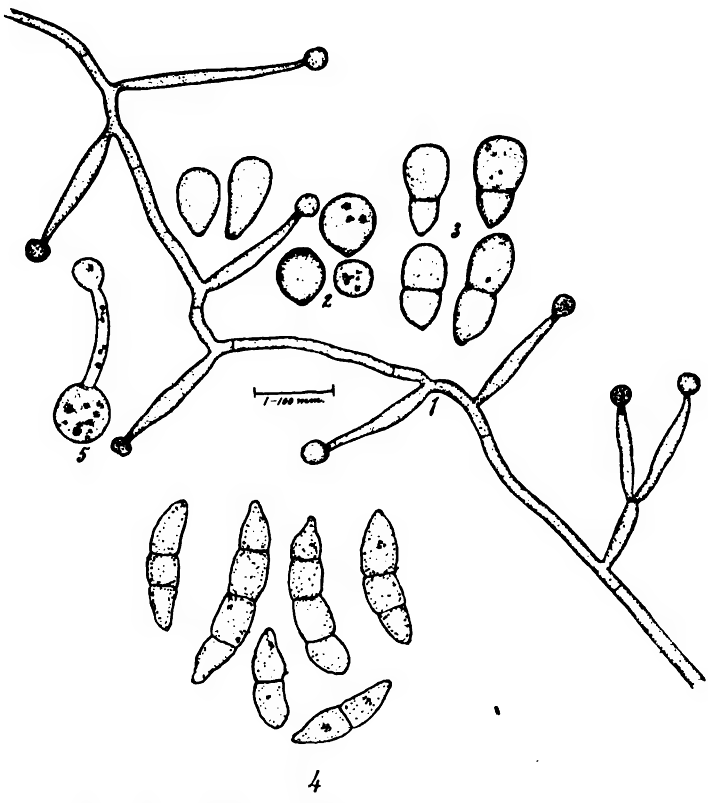

PLATE XIII.—*Sporotrichum poæ* PK., THE FUNGUS OF CARNATION BUD-ROT.

1, Hypha with immature spores on short, tapering branches. 2, Three mature spores of typical form. 3, Two-celled, pear-shaped spores. 4, Fusarium-like spores. 5, Germinating spore with new spore forming at tip of short germ-tube.

(1, 2, 3 and 5 drawn with aid of camera lucida, magnification about 1000 diameters; 4 free-hand drawing, more highly magnified.)

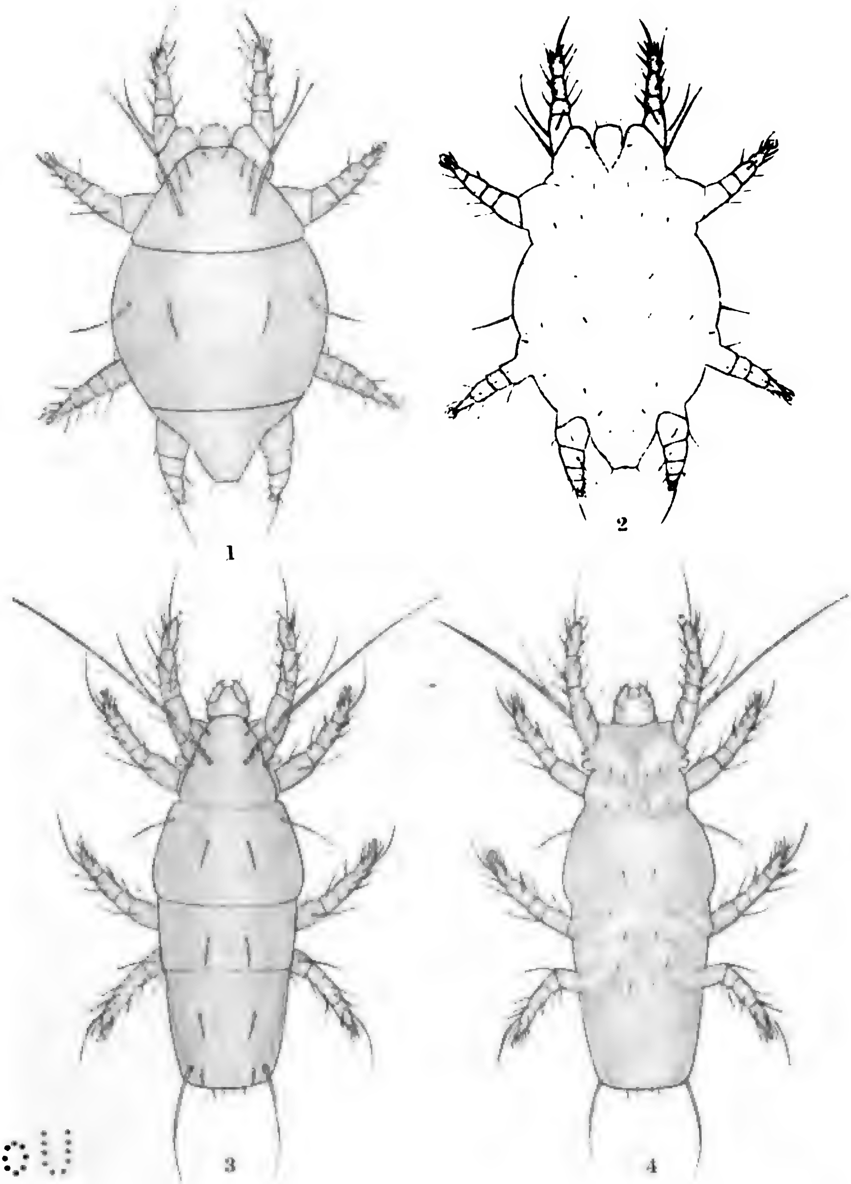

PLATE XIV.—*Pediculopsis graminum* REUT.

1, Male, dorsal view. 2, Male, ventral view. 3, Female (non-gravid), dorsal view. 4, Female (non-gravid), ventral view. All adults, greatly enlarged.

THE MITE, *PEDICULOPSIS GRAMINUM* REUT.[31]

The insect pests and fungus diseases incident to the commercial growing of carnation blooms may usually be held in check by certain recognized practices and as far as the common pests are concerned no especial difficulty has been experienced in raising plants free from important injuries. But within the past few years, considerable uneasiness has been experienced by a number of florists because many carnation buds fail to mature and the growers are unable to prevent losses by the usual greenhouse practices. An examination of diseased plants showed that the failure of the buds to produce perfect blossoms was due to the presence of a mite and fungus, which together cause a decay of the tenderer tissues that eventually arrests the growth of the buds.

The mite has been recognized as *Pediculopsis graminum* Reut., which is a European species and has not heretofore been recorded in this country. This is one of the forms assisting in the premature ripening of meadow grasses in Finland, and in the United States is partly responsible for the silver top of June grass. Its presence in the greenhouse appears to be accidental but its association with the fungus enhances its importance and hence the economic status of the mite.

Acknowledgments are due to Dr. Enzio Reuter, Helsingfors, Finland, who has verified the determination of the species and has furnished valuable information concerning the grass mites. Mr. J. J. Davis, Field Entomologist for Northern Illinois, very generously allowed me the use of all his notes on the occurrence of the mite in that state and has from time to time contributed other important facts, as opportunity has been afforded for making observations. Dr. F. D. Heald, Botanist of the Nebraska Experiment Station, very kindly sent infested carnation buds from Lincoln, Nebraska, from which adult mites of both sexes were obtained.

HISTORY.

The importance of this species as an active agent in the premature ripening of grass stems was first indicated during the year 1900 by Dr. Enzio Reuter[32] under the caption "Ueber die Weissäh-

[31] By H. E. Hodgkiss.

[32] *Acta Societatis pro Fauna et Flora Fennica*, 19: N:o 1. 1900.

rigkeit der Wiesengräser in Finland." No mention is made of this mite in Banks' Lists of the Acarina of the United States,[33] and its identity in this country appears not to have been determined until the present time.

As an active agent in the decay of carnation buds it was first mentioned by Dr. R. H. Wolcott[34] in 1905, and during the following year was recognized in New York State. One year later the mite was identified at this Station as *P. graminum* Reuter. Finally in 1908, Heald and Wolcott published an account of the species under the name *Pediculoides dianthophilus.*[35]

SYSTEMATIC POSITION.

This species belongs to the Tarsonemidæ, which is a small family of the order Acarina. The mite was first described in 1900, by Dr. Enzio Reuter, from specimens taken from grass in Finland. He placed it in the genus *Pediculoides,* and gave to it the specific name *graminum.* In 1907, Dr. Reuter again published on this species at this time indicating the presence of characters of generic significance. He thereupon erected the genus *Pediculopsis,* naming *P. graminum* as the type.[36]

IDENTITY OF THE SPECIES AND SYNONOMY.

The very close resemblance between our mounts of the mite grown on carnations with the figures of Reuter's *P. graminum,* suggested the sending of specimens to him for examination which he determined as identical with the species which he had described as existing on grasses. It would appear therefore, that there can be no doubt as to the specific name of the mite grown on carnations in this State. Specimens of the mite thriving on diseased carnation buds in Nebraska were sent to us by Professor Heald of the Experiment Station which proved to belong to the above species as found on the same host in this State. It therefore appears that *P. dianthophilus* Wolcott is a synonym of *P. graminum* Reuter.

[33] Proc. U. S. Nat. Mus., 32: 615.
[34] *Science,* N. S., 21: 389. 1905.
[35] Neb. Sta. Bul. 103. 1908.
[36] "Wegen bedeutender Unterschiede, namentlich in der Mundbildung, der Gattung *Pediculoides* gegenüber, habe ich in der demnächst erscheinenden grösseren Arbeit für diese Art eine neue Gattung, *Pediculopsis,* errichtet." *Festchrift für Palmén.* N: 7, p. 3, footnote 2. Helsingfors. 1907.

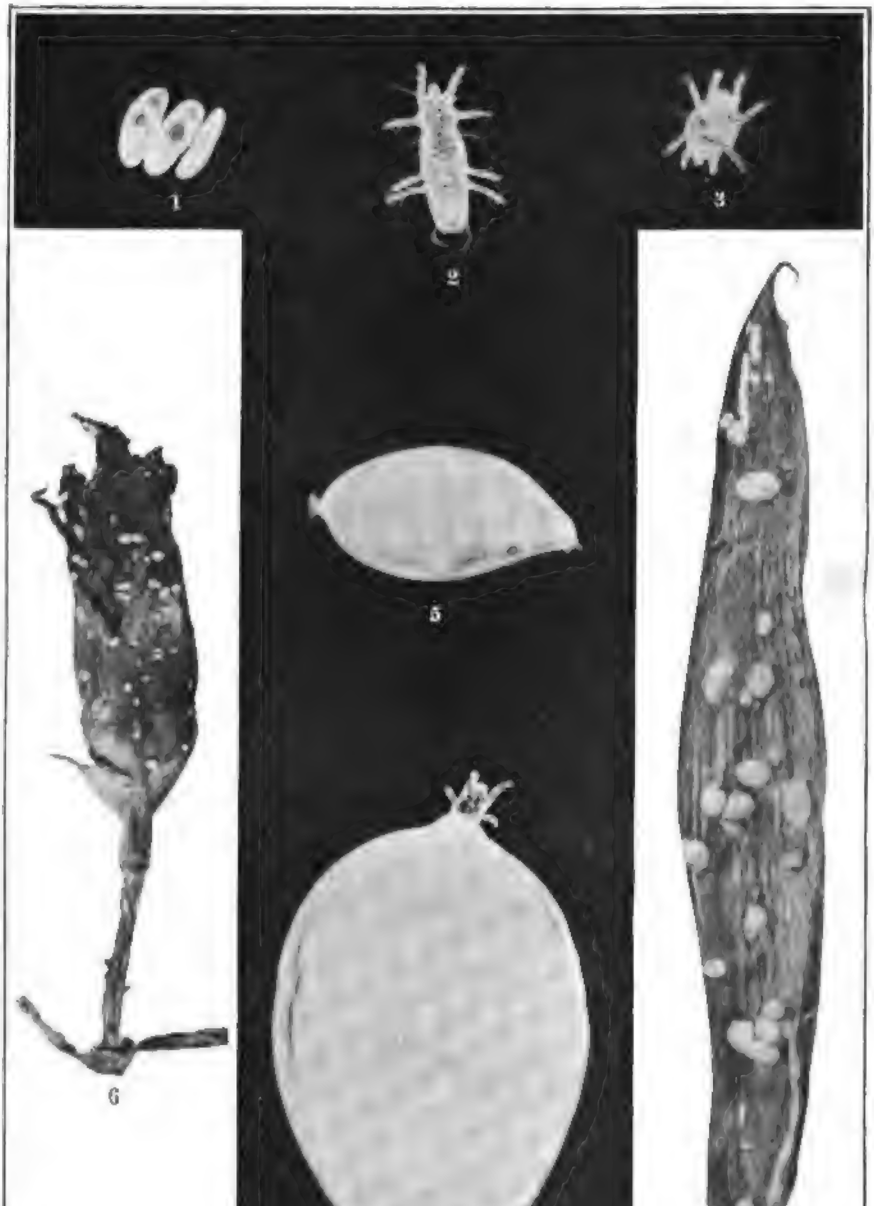

PLATE XV.— LIFE STAGES OF *Pediculopsis graminum* REUT.

1. Eggs. 2, Adult female. 3, Adult male. 4, Gravid female. 5. Gravid female, with extruded egg. 6 and 7, Gravid females from breeding cage. (6, natural size, other figures enlarged.)

DESCRIPTION AND LIFE HISTORY.[37]

Egg.— Ovum elliptical; chorion translucent, smooth, shining. Longest diameter 204 microns, greatest width 85 microns.

Adult.—(Female.) Body elongate, sides nearly parallel, anterior portion narrowing to head, posterior margin truncate; lateral angles rounded. Length, 240 microns, width 70 microns.

The body is composed of a cephalo-thorax and abdomen. On the anterior margin of the cephalo-thorax is the rostrum with large, toothed, sickle-shaped mandibles. The rostrum is set in a wide collar which is attached to the body. There are several small hairs near the base of the mandibles.

The cephalo-thorax is somewhat triangular, broadest at the posterior margin, with angles rounded and sides incurved. Legs I and II are borne on this division and between them is a clavate body. On the dorsum there are three pairs of long hairs; the front pair smallest, about 12 microns in length; the middle pair about 20 microns in length and situated closer to the lateral margin than the third pair. The third pair are almost in the center of the cephalo-thorax and directly beneath pair I; they extend nearly to the end of the abdomen. The clavate organ is broadly rounded.

The abdomen is separated from the cephalo-thorax by a transverse constriction. Caudad of this are several telescoping portions of the integument which give the abdomen a segmented appearance. On the dorsum about 12 microns behind the transverse constriction and near to the lateral margin is a pair of strong hairs about 33 microns in length; just below these and 15 microns from the median is a stout pair 17 microns long; three other pairs of dorsal hairs are situated just below the caudal margin of the telescopic integument, the last pair being the shortest. A single pair 75 microns long is borne near the end of the ventral section and is the longest pair on the abdomen. On the caudal margin near the median are three pairs of very small hairs, the longest being 10 microns in length.

[37] While the external anatomy of the mature mites bred on carnations corresponds with the descriptions and figures of the adults of *P. graminum*, our studies on the early life history of the species do not agree in some particulars with Reuter's account. This difference may perhaps be explained by his recent investigations on the embryonic development of this mite.

The ventral surface of the cephalo-thorax and abdomen bear characteristic short spines, placed regularly in pairs. These are indicated in Plate XIV, fig. 4.

The legs are five-jointed and strongly haired, the longest hairs being always on segments 2, 4 and 5. The first pair of legs have each a single hooked claw; the claws on the other legs are paired and provided with a stalked suction gland. The epimera have a strong chitinous protection and meet along the median.

Adult.—(Male.) Body broadly egg-shaped; narrowing in the front while behind at the genitalia it is produced blunt and cone-shaped. Length about 160 microns, the greatest width 60-80 microns.

Rostrum very small, a round knot-like structure without mouth-parts. Cephalo-thorax similar to that of the female, but more broadly rounded. It bears four pairs of hairs, the first pair being very small and placed near the forward margin, the second ten microns long and the third twice as long as the second and nearer to the lateral margins. These three pairs are situated behind each other in lines almost parallel with the lateral margins. The fourth pair are almost directly behind the third pair, 53 microns long and very stout.

The cephalo-thorax and abdomen are separated by a transverse constriction. About 16⅔ microns behind this are a pair of stout hairs 33 microns long, situated near the lateral margin, while between these and about 17 microns from the median are two shorter hairs. Just anterior to legs IV is a constriction behind which the body narrows cone-shaped to the genitalia. Legs I to III are similar to those of the female. Legs IV are much thicker, incurved, and each bears a terminal sickle-shaped claw. Short hairs are borne on each segment while on the last two are blunt spines. The terminal segment has a single, long hair at the base of the claw.

The ventral surface has characteristic, small spines the location of which is shown in Plate XIV, fig. 2.

Gravid female.— The difference between the gravid and non-gravid female is in the enormous size of the abdomen. This swelling extends backward from the cephalo-thoracic constriction and does not include the thorax as in some other forms. When extended, the abdomen may become 80 to 100 times as large as the unimpregnated female or even larger. During the extension of the

abdomen and the embryonic development within, it becomes translucent and appears as a clear pearl-like body.

The development of this mite from the time the egg is formed until the adults appear takes place within the amnion in the abdomen of the female. The abdomen of the adult female begins to extend shortly after impregnation and fills with a water-clear liquid. A series of observations made at this period indicates that the interval between the date on which distention begins and that on which eggs appear in the sac is from two to four days. From this time the eggs continue to develop rapidly and in about fifteen days the sacs are full and contain two hundred or more eggs.

The sac takes on a pinkish color as the mites develop and in about three weeks from the time of swelling both males and females of the new generation are fully mature. The sac now disintegrates and in its place is a mass of crawling adults. In only one instance has a female been seen to deposit an egg and in that case the abdomen finally broke and liberated the adults. (See Plate XV, fig. 5.)

The newly hatched mites remain together for a short time and then wander over the plant feeding on the succulent tissues. For about ten days they crawl freely and then the abdomen begins to swell. The females soon become fixed, often on decaying tissue, and with the appearance of eggs within the abdomen the life cycle of another generation begins.

The number of generations which occur with this species is somewhat difficult of determination. Individuals of the several stages may be seen throughout the year. As far as the data obtained are concerned there appear to be at least two full generations and a possible third generation where the species breeds in grass. In Finland, Dr. Reuter has found two generations. From observations made on diseased carnation buds in the greenhouse there appear to be at least two additional generations.

GEOGRAPHICAL DISTRIBUTION.

The mite has a wide geographical range. It has been recorded in Europe as occurring in Finland. In the United States it has been taken in widely separated sections of New York State and Illinois and in Nebraska.

FOOD PLANTS; CHARACTER OF INJURY.

In Europe this species has been taken from the stems of *Phleum pratense, Poa pratensis, Agropyron repens, Festuca rubra, Deschampsia caespitosa, Avena pubescens, Agrostis vulgaris, A. alba, Apera spica venti, Anthoxanthum odoratum* and *Alopecurus pratensis*. In this country it has been collected from June grass (*Poa pratensis*), *Phleum pratense*, and in greenhouses from carnation buds.

The work of the mite on grass and on carnations is quite dissimilar. On grass it attacks the succulent stem within the sheath just above the topmost node. According to Reuter the culm is first lacerated by the mandibles and then the plant juices are extracted, causing the injured area to shrivel gradually and become twisted at or just above the node. The growth of the stem above this point is checked, causing the partially opened panicles to ripen prematurely and giving rise to the condition known as silver top. We have repeatedly examined grass stems for injuries of this character but have entirely failed to find conclusive evidence of the exact nature of the damage to our local grasses by the mite. The initial injury is apparently not easily detected and in the general decline of the affected stem the wounds are apparently obscured and are not easily recognizable from the work of other agencies. In the early spring a decay of the injured portion of the stem is usually found. It always appears when the area attacked is close to the ground where the presence of moisture is favorable for its growth. This decay is due to the *Sporotrichum poæ* before mentioned. The mites have been found breeding more freely under these conditions than upon the more exposed culm.

On carnation plants the mite does not attack the stem but works into the center of the young buds. Here it introduces the same fungus with which it is associated on grass. Experiments made for the purpose of determining the point of attack indicate that the stamens or pistils are first attacked and later the less tender tissues. The fungus here finds a favorable condition for growth and in a comparatively short time the heart is entirely decayed and filled with mites while the growth of the buds is checked.

INOCULATION EXPERIMENTS WITH MITES.[38]

These experiments consisted of a number of artificial infections of carnation buds in various stages of growth of the buds to determine the range of susceptibility to the attacks of the mite. Two series of experiments were made. In one series mites were used which were obtained from infested buds, and in the other, active females were employed, which were treated with a pure culture of the fungus.

In the first series the following experiments were made with buds at different stages of growth. Buds I and II had the petals just broken through the sheath. Each was infested with four gravid females, which were placed within by forcing aside the petals at the top. Twenty days later both buds had opened and showed no injury. The mites had died and the fungus caused no perceptible damage. Bud III was well formed, of good size, and the sheath was tightly closed. The infection was made by placing several crawling females and one gravid female into the heart of the bud through an opening in the side. Twenty days later the record shows that the bud had enlarged to twice the original size but was dry, and on opening it the interior was found to be undeveloped. Buds IV and V were similar in condition to I and II. These were each infected with two gravid females. The buds opened in due season with a perfect bloom.

In the second series seven buds were inoculated with a goodly number of crawling females and pure cultures of the fungus. These buds were on plants in an ordinary carnation bed and were more or less attacked by thrips. None of the infested buds showed signs of injury and all eventually came to a perfect bloom.

Although with one exception these inoculations brought negative results, it has been thought best to make a record of the work. The failure to reproduce the typical injury may be due to several causes. Among these are lack of proper conditions for the growth of the fungus and the variety of carnations used in the work. The successful experiment would indicate that the infection to cause typical injury must be made to younger buds.

[38] By H. E. Hodgkiss.

RELATION OF THE MITE TO THE FUNGUS.[39]

The relation of the mite to the fungus is not entirely clear. From the inoculation experiments which have been made it appears that the fungus rather than the mite is the active agent in producing the disease. Bud-rot has been produced repeatedly by artificial inoculation with pure cultures of the fungus; whereas, attempts to produce the disease by inoculation with mites alone have failed. Moreover, in the cases of bud-rot produced by inoculation with pure cultures of the Sporotrichum no mites have ever been found in the decayed tissue. Thus, it is plain that the mite is not absolutely necessary to the production of the disease. Neither can the association of the mite with the fungus be satisfactorily accounted for on the ground that *Pediculopsis graminum* is an abundant species infesting decaying carnation tissue generally, for such is not the case. In our studies the mite has never been observed alone, but always in association with the fungus. Whether the fungus is always accompanied by mites can not be so definitely stated. In a few cases, particularly on June grass, the mites have been absent, apparently, but it is possible that more careful search would have revealed their presence.

This almost constant association of the mite and the fungus leads to the inevitable conclusion that one must be in some way dependent upon the other. Regarding this there seem to be but two hypotheses which harmonize at all with the known facts: (1) That the mite feeds upon the Sporotrichum; (2) that the fungus depends on the mite to carry it from bud to bud.

We have been unable to obtain any positive evidence that the mites feed on the Sporotrichum. The chief reason for suspecting that such might be the case is the fact that Forbes[40] has observed mites feeding upon another species of the same genus, viz., *Sporotrichum globuliferum*. Webster,[41] also, records the occurrence of mites (*Tyroglyphus siro*) in artificial cultures of *Sporotrichum globuliferum*, but thinks they were attracted by the corn meal batter on which the Sporotrichum was growing. Sometimes mites make

[39] By F. C. Stewart and H. E. Hodgkiss.

[40] Forbes, S. A. Ills. Sta. Bul. 38: 32; same on p. 94 of second reference given in footnote No. 4.

[41] Webster, F. M. The common cheese mite. *Tyroglyphus siro*, living in *Sporotrichum globuliferum*. Ann. Rpt. Ent. Soc. Ontario 32: 73. 1902.

trouble in the laboratory by getting into fungus cultures, but whether they feed upon the fungi or upon the culture medium is not clear.

Concerning the second hypothesis it is plain that the mites may carry the spores from bud to bud and thus spread the disease, but in order to account for the constant association of the mite and fungus it is necessary to go further and establish a motive for the mites visiting the buds. If the mites go to the diseased buds merely to feed on the decaying tissue or to breed in it there would be no object in visiting healthy buds. Although we have been unable to demonstrate it, it seems probable that the mites *do* visit healthy buds, presumably for the purpose of feeding upon the tender tissue of the floral organs. This would be quite in harmony with the known feeding habits of this species, it having been established by Reuter[42] that it attacks the tender living tissue of grass culms. As previously stated, our attempts to produce bud-rot by means of the mites alone, have failed. Altogether, 12 buds were inoculated with mites, apparently without any injurious effect on the buds. However, the negative results in these few experiments have little weight. The conditions surrounding the plants may have been unfavorable to the mites.

The fact that the disease sometimes destroys the interior portion of the buds before the latter have even begun to open, is strong evidence that the spores of the fungus are carried into the buds by some animal. It seems scarcely possible that the spores could get into such tightly closed buds in any other way. In such a situation suspicion would naturally point to thrips, two or three species of which frequently attack carnations and often enter the buds. However, our studies tend to exonerate thrips of any connection with the disease. Mites are the only animals found in the diseased buds.

Some species of Sporotrichum are parasitic on insects, and Kirchner[43] has observed a species of Sporotrichum apparently parasitic on the mite *Tarsonemus spirifex* Marchal, but there is no reason to suspect that *Sporotrichum poæ* bears such a relation to the mite in the carnation buds.

To sum up: The hypothesis which offers the most rational explanation for the constant association of the mite and the fungus

[42] Reuter, Enzio. (See footnote No. 15.)

[43] Kirchner, O. Eine Milbenkrankheit des Hafers. *Ztschr. Pflanzenkrank* 14: 13–18. 1904.

in diseased carnation buds is the following: The mite visits healthy carnation buds for the purpose of feeding on the tissue of the floral organs. Spores of the fungus carried on or in the body of the mite germinate and produce a mycelium which attacks the interior portions of the bud and causes them to decay. In this decaying tissue the mite finds a congenial breeding place. When the young mites are able to travel they migrate to healthy buds carrying with them the spores of the fungus.

The above applies especially to carnations. Probably, it applies also to June grass, but the association of mite and fungus on June grass seems to be much less constant.

CONTROL OF CARNATION BUD-ROT.[44]

Probably, bud-rot will rarely be sufficiently destructive to require special methods for its control. If this be true it is fortunate, because there is, as yet, no line of treatment which can be confidently recommended. The Station has made no experiments along this line.

Certainly, all diseased buds should be carefully gathered and burned, because they contain countless numbers of fungus spores and mites by means of which the disease is spread.

Another possible line of treatment is the elimination of susceptible varieties. Although several varieties are more or less subject to bud-rot it is destructive to only a few varieties chief among which are Lawson, Enchantress and Bradt.

The fact that bud-rot is a fungus disease suggests that the carnations should be kept as dry and cool as is compatible with good growth, because it is well known that abundant moisture and high temperature favor the growth of fungi. However, in this case, another factor, the mite, must be taken into consideration. There is good reason to believe that the mite is an important factor in spreading the disease. While nothing is known as to the effect of moisture on this particular mite it is known that mites in general thrive best under dry conditions.

The fact that the mite associated with bud-rot is one which feeds on various grasses, particularly June grass, suggests that the planting of carnations near grass land or the use of sod in the preparation of greenhouse soil may encourage bud-rot. Excepting the observations made by Mr. Davis in Illinois (p. 144) we have no

[44] By F. C. Stewart and H. E. Hodgkiss.

direct evidence on this point. It should be noted, however, that although the use of sod soil in carnation houses is a common practice and the silver top of June grass is a common and widespread trouble, carnation bud-rot is comparatively rare. Moreover, it is quite possible that other plants besides grass and carnations harbor the bud-rot Sporotrichum and the mite. Hence, it is doubtful if it is worth while to attempt to prevent bud-rot by eliminating grass and sod from carnation culture.

DISCUSSION OF NEBRASKA STATION BULLETIN No. 103.

"THE BUD-ROT OF CARNATIONS, BY F. D. HEALD."[45]

With the exception of one topic, Inoculation Experiments with Fungus, the senior author had practically completed his part of this bulletin before the appearance (in January, 1908) of Nebraska Station Bulletin No. 103 on the same subject. In order to avoid rewriting some parts we shall present here our comments on Dr. Heald's work.

In the main, Heald's observations and deductions agree quite closely with our own. Some of the principal points of agreement are the following:

(1) The buds are the only part of the carnation plant affected (p. 14).

(2) The Sporotrichum exists in the rotting petals in all cases and generally unaccompanied by other fungi (p. 9).

(3) A mite is constantly associated with the Sporotrichum in affected buds (p. 9).

(4) The Lawson variety is especially susceptible to bud-rot (p. 13).

(5) The Sporotrichum alone is capable of producing the disease (p. 9).

(6) The most typical development of the disease was obtained from the inoculation of young buds (p. 9).

(7) The mite plays only a secondary part in the production of the disease — it acts as the carrier of the fungus spores (p. 10).

(8) In artificial cultures the Sporotrichum produces a deep red color (p. 12).

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[45] By F. C. Stewart.

(9) The Sporotrichum produces two kinds of spores,—one, globular and non-septate, the other elongated and generally once-septate (p. 11).

(10) All affected buds should be picked and burned as soon as they appear (p. 15).

Heald's figures in his Plate I show well the tendency of the fungus to produce its spore-bearing branches in clusters. These figures represent better than do our own the usual habit of the fungus as it is found in diseased carnation buds. Our own figure (Plate IV, fig. 1) was made from one of the simpler forms of hyphæ which occur when the fungus is growing very rapidly in a moist chamber.

On page 11 Heald says: "In some cases in crowded cultures the hyphæ may give rise to new conidia at their tips without any branching or on very short lateral branches (pl. III, fig. 18)." The writer has observed the same phenomenon in cultures on cooked apple in petri dishes (See Plate XIII, fig. 5). Since this premature spore formation was especially common in a certain culture which for some unknown reason made a very scant growth, we incline to the opinion that it was induced by unfavorable growth conditions.

We do not agree with Heald that bud-rot is necessarily a disease of neglected houses and not likely to prove troublesome in greenhouses that are kept in prime condition (p. 12). The Long Island greenhouses in which bud-rot has been troublesome during the past three years are exceptionally well managed.

Probably, Heald's better success with inoculation experiments is due to the fact that he used a very susceptible variety. In determining the results of inoculation we (unlike Heald) *have* relied upon general appearance and microscopic examination. In a case of this kind Heald's method of reisolation (p. 10) serves no useful purpose except to give the impression that the experiments were conducted with exceptional care. But the accuracy of his work is discredited by the fact that after making a series of his careful (?) inoculation experiments[46] with pure cultures he referred the fungus to the genus Fusarium, and then, subsequently, explained the error as follows (p. 4): "It was found later that the trouble

[46] "Pure cultures were made of the fungus, and successful inoculations were carried out. The fungus was again isolated and new inoculations made which indicated that the fungus alone was capable of producing the rotting." (*Science*, N. S., 23: 620. 20 Ap. 1906.)

was due to a different fungus, and that the Fusarium was a contamination which developed during the transit of the specimens."

"A MITE ACCOMPANYING THE BUD-ROT OF CARNATIONS, BY ROBERT H. WOLCOTT."[47]

This chapter of Nebraska bulletin No. 103 contains a brief discussion of the life history and the description of a mite which Dr. Wolcott says "may appropriately be designated as *Pediculoides dianthophilus*."

The life history as given on p. 26 agrees quite well with that of the mites infesting carnation buds in New York State and Illinois and those in the buds received from Lincoln, Nebraska. The description and figures of *Pediculoides dianthophilus,* however, are somewhat misleading. This is particularly true of the figure of the male although the position of the hairs on the dorsum of the female is not correct. The first or lateral pair of hairs situated just behind the transverse constriction is not figured. The three pairs of median hairs figured in the plate are too near the lateral margins.

The description and figure of the male are entirely wrong, and it would appear that the figure of the male has been reversed thus giving one the impression that the knot-like head with its fringe of hairs is a part of the genitalia, while the other end of the body is provided with a head and mandibles similar to those of the female. Aside from these points of difference the structural characters of the cephalo-thorax of the male and female resemble each other so closely that it would appear to be impossible to mistake which is the cephalic end of the body, even if one were not acquainted with the usual structure of male genitalia. The copulatory organ of the male is typical of the family to which the species belongs.

There is no question as to the correctness of the above observations as the male specimens from which my illustrations were made were obtained from carnation buds sent me by Professor Heald as the species upon which he and Dr. Wolcott were working at the time.

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[47] By H. E. Hodgkiss.

TROUBLES OF ALFALFA IN NEW YORK.*

F. C. STEWART, G. T. FRENCH AND J. K. WILSON.

SUMMARY.

New York farmers are becoming much interested in alfalfa culture and the acreage of this crop in the State (5582 acres in 1899) is rapidly increasing. This bulletin gives an account of the various hindrances to successful alfalfa culture in New York.

Undoubtedly, the chief difficulty is to get the crop established. Several factors may be concerned in this: Poor seed, poor fitting of the seed-bed, sour soil, wet soil, sowing with a nurse crop, lack of nodule bacteria, lack of humus, weeds, leaf spot disease, close cutting and winter injury. Dodder is often a serious pest and leaf spot (*Pseudopeziza medicaginis*) is an important fungus disease.

No alfalfa seed is produced in New York. Much of the seed used here is imported and the remainder comes from the Western States. Farmers experience much difficulty in obtaining good alfalfa seed. It is aften impure, containing dodder, English plantain, wild carrot and divers other troublesome weeds. Sometimes it is adulterated with seed of yellow trefoil, bur clover and sweet clover. To avoid trouble from this source farmers should submit samples of their alfalfa seed to the Experiment Station for examination. In 548 samples of alfalfa seed examined by the Station during the past two years 126 contained dodder. If dodder-infested seed is used it should first be sifted in a 20 x 20 mesh sieve made of No. 34 steel or iron wire. Dodder is a dangerous weed and no chances should be taken with it. Fields badly infested with dodder should be plowed up and reseeded. If there are only a few dodder spots they may be dug out or, better yet, burned out, using kerosene and hay for fuel. Dodder does not commonly produce seed in New York alfalfa fields. It is carried over from one year to the next chiefly by means of hibernating threads on the crowns of the plants; that is to say, *dodder is perennial* not annual as generally believed. The number of kinds of dodder occurring on alfalfa in New York is not known. *Cuscuta epithymum* is the most common species. Usually, the reseeding of dodder-in-

* A reprint of Bulletin No. 305.

fested fields may be accomplished without the reappearance of dodder in the new seeding provided dodder-free seed is used.

Yellow trefoil closely resembles alfalfa, but it has a yellow blossom whereas alfalfa has a purple one. Another striking difference is found in the root-systems of the two plants. Alfalfa has a strong tap-root with few side roots, while the tap-root of yellow trefoil is smaller and has numerous side roots. Yellow trefoil is not a troublesome weed; it is merely a worthless plant. In New York, yellow trefoil is regularly a biennial in alfalfa fields and lawns. It becomes conspicuous in the first cutting of the second season, then disappears. The adulteration of alfalfa seed with yellow trefoil is much less frequent than it was a few years ago.

In newly-seeded alfalfa fields weeds are a serious menace. Before seeding with alfalfa the land should be cleaned thoroughly. It is folly to sow alfalfa on foul land. Practically all of the trouble with weeds comes during the first season. In established alfalfa fields few weeds are able to maintain themselves. When weeds threaten to smother young alfalfa the field should be promptly clipped, but not mown closely. Close mowing may ruin young alfalfa.

The only really important fungus disease of alfalfa in New York is the leaf spot caused by *Pseudopeziza medicaginis*. Other diseases sometimes found are wilt (*Sclerotinia libertiana*), anthracnose (*Colletotrichum trifolii*), downy mildew (*Peronospora trifoliorum*), Ascochyta leaf spot (*Ascochyta sp.*), Stagonospora leaf spot (*Stagonospora carpathica* (?)), and Cercospora leaf spot (*Cercospora medicaginis*). In germination tests, dead, brown seeds commonly become overgrown with a species of Alternaria, but whether the fungus is parasitic or saprophytic is not clear.

Frost blisters occur on the under surface of alfalfa leaves after every frost. A root-knot disease caused by nematodes is common but probably not important. There appear to be no very important insect enemies of alfalfa in New York.

There were found four diseases the cause of which could not be determined, viz.: White spot, an unimportant disease of alfalfa leaves; yellow top, which causes the plants to stop growing and turn yellow; pitting of the tap-root, due to the gnawing of some unknown animal, and a blackening of the fibro-vascular bundles in the tap-root. There was found, also, a freak alfalfa plant having unifoliate leaves throughout.

INTRODUCTION.

PURPOSE AND SCOPE OF THIS BULLETIN.

The purpose of this bulletin is to give an account of the hindrances, both great and small, to the successful culture of alfalfa in New York; to state their relative importance, their nature and distinguishing characters and the best means of overcoming them. Special attention is given to dodder, fungus diseases and the impurities and adulteration of seed. Along several lines there is a regrettable lack of data. Some of the topics are treated only briefly because they do not properly belong in the province of the Botanical Department. In order to facilitate the labors of those who wish to pursue the subject further, an attempt has been made to make the list of alfalfa diseases complete. Following the discussion of the diseases of alfalfa in New York there is given a list of other alfalfa diseases not known to occur in the State.

ALFALFA AS A FARM CROP IN NEW YORK.

According to Dawley[1] the successful culture of alfalfa in New York dates from 1867. On the Station farm it has been grown continuously and successfully since 1882. The Federal Census for 1900 gives the total acreage of alfalfa in the State as 5,582 acres which yielded 13,002 tons of hay. Over four-fifths of the entire acreage was then in three counties in the central portion of the State; viz.: Onondaga (3,767 a.), Madison (588 a.) and Oneida (212 a.). The remaining acreage was divided among 36 counties with from 1 to 87 acres each. At the present time, the acreage must be considerably larger and somewhat more uniformly distributed. During the past few years interest in alfalfa has been growing rapidly. With a better knowledge of the requirements of the plant it is now grown successfully in every agricultural county in the State. However, there are many localities in which alfalfa culture is still in the experimental stage.

It is grown chiefly for hay, being cut two to four times each season according to weather conditions and fertility of the land. It is used to a considerable extent, also, as a soiling crop. Sometimes it is put into the silo either alone or mixed with corn. It is

[1] Dawley (22). The number in parenthesis refers to the bibliography at the end of this bulletin.

seldom pastured and no seed is produced. While fed more or less to all farm animals it is regarded as especially valuable for milch cows.

VARIETIES GROWN.

The botanical name of alfalfa is usually given as *Medicago sativa* L.[2] There are but a few named varieties. Very little is known as to the value of the different varieties of alfalfa for New York conditions. New York farmers, when buying alfalfa seed, seldom inquire about the variety or where the seed was grown. Much of the seed used is imported from Europe, Asia and South America and the remainder comes from various parts of the western United States. There is no home-grown seed available.

THE CHIEF DIFFICULTIES.

The greatest difficulty with alfalfa culture in New York is to get the crop established. Several factors may be concerned in this: Poor seed, poor fitting of the seed bed, sour soil, wet soil, sowing with a nurse crop, lack of nodule bacteria, lack of humus, weeds, leaf spot disease, close cutting and winter injury. If the first winter is passed safely the chances of ultimate success are excellent. Dodder (*Cuscuta* spp.) is often a serious pest, being sometimes so destructive as to necessitate plowing up the crop. Leaf spot (*Pseudopeziza medicaginis*) is a common disease causing enormous loss in the aggregate, although seldom ruining the crop completely. Heavy losses also result from the frequent rains in June which often prevent proper curing of the first cutting.

UNCONGENIAL SOIL CONDITIONS.

Some common causes of failure with alfalfa fall under this head. However, the discussion of them here will be brief for two reasons: First, because the writers have been unable to give much attention to this phase of the subject, and; second, because the Bacteriological Department of the Station has under way special investigations covering parts of the field.

POOR FITTING.

All writers on alfalfa agree that the land should be very thoroughly fitted. It should be disked, rolled and harrowed until it is

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[2] For the botany of alfalfa see Brand (6, p. 18) and Scofield (92). According to the latter the correct name of alfalfa is *Medica sativa* (L.) Mill.

in fine garden condition. In New York, as elsewhere, this important matter is frequently neglected.

ACID SOIL.

In other states[3] and other countries it has been found that frequently a dressing of lime is an important aid in securing a stand of alfalfa. Some experiments made by the Cornell Experiment Station[4] and the experience of farmers show that the same is true in New York. It is believed that the success of alfalfa in Onondaga county is due, in large part, to the large amount of lime in the soil there. What proportion of the soils of the State require liming before alfalfa may be grown upon them successfully is not known. The Bacteriological Department of the Station has in progress some experiments which are expected to throw light on this point, but the results are not yet available. It is the popular opinion that the soil on many of our farms is too acid for alfalfa.

WET SOIL.

An excess of water in the soil is another serious trouble of alfalfa. It should be understood that alfalfa will not thrive on wet land. Just what degree of wetness is prohibitive to alfalfa culture can not be stated. Coburn,[5] of Kansas, says that alfalfa does not do well where water is nearer to the surface than six feet or where in winter water will stand on the ground for over forty-eight hours. In New York, a fair degree of success has been attained, frequently, with the water table considerably nearer the surface than six feet. Where water stands within three feet of the surface it is unwise to attempt to grow alfalfa. The usual symptoms of "wet feet" are stunted growth and yellowish or reddish discoloration of the foliage.

Although it was in New York that tile drains were first used, there are still large areas of agricultural land in the State needing underdrainage badly. It appears that the benefits of underdrainage are not yet fully realized by many of our farmers.

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[3] Miller (66); Williams and Kyle (109); Hopkins (47); Duggar (24).

[4] Hunt, *et al.* (48).

[5] Coburn (15, p. 44).

[6] A discussion of heaving is given by Sorauer (97, 1: 65).

HEAVING.

Considerable damage is done by the so-called "heaving" of the plants which is quite as common with alfalfa as with red clover and due to the same cause, alternate freezing and thawing when the surface layer of the soil is filled with water.[6] Newly seeded fields suffer most, but fields of any age may be affected. This trouble was unusually common and severe in New York in the spring of 1904. Prof. Stone[7] says: "About the first day of May [1904] the writer saw fields of alfalfa of the previous spring's seeding where three-fourths of the plants were thrown out upon the surface of the soil so completely that they could be gathered up by handfuls like so much straw."

The effects of heaving are best observed during the latter part of April. It is most severe in the wetter portions of the field. Sometimes nearly all the plants are killed out over large areas the boundaries of which are fairly well defined, but the trouble is more likely to take the form of thin spots of irregular shape and indefinite outline. In mild cases, when only a few affected plants are scattered here and there each spring, the trouble may pass unnoticed until in the course of a few years the alfalfa becomes "run out." The plants may be lifted completely out of the ground and left lying on the surface or they may remain standing with one to four inches of the tap-root exposed. If the plants are lifted as much as four inches death usually results; in less severe cases recovery is frequent although the plants never regain their normal position and the foliage.

Thorough drainage is the approved remedy for heaving. However, there are instances in which the drainage is apparently good yet the land heaves. Such a case is mentioned by Watson.[8]

HARDPAN.

Most writers on alfalfa regard the character of the subsoil as very important. Miller[9] says that "the subsoil seems to be the controlling factor in the successful growing of alfalfa in Missouri." Where the subsoil is of the hard, impervious kind known as hardpan, alfalfa is not likely to succeed unless the land is very thoroughly underdrained and other conditions are favorable. Doubtless,

[6] A discussion of heaving is given by Sorauer (97, 1:65).
[7] Stone (99, p. 6).
[8] Watson (106).
[9] Miller (66, p. 13).

some of the failures with alfalfa in New York are to be attributed to hardpan. Stone,[10] after reviewing the experiences of the spring of 1904 when alfalfa in New York was found badly winterkilled says: "This indicates that while alfalfa may succeed on lands with somewhat impervious subsoils, yet on such subsoils the crop is much more liable to damage than upon those of a more porous nature."

There has come to our attention one quite remarkable case of success with alfalfa over hardpan. A farmer at East Bloomfield, N. Y., entered into an agreement with the Bacteriological Department of the Station to conduct a coöperative experiment on soil inoculation for alfalfa. The plat of land used contained one acre and was so situated on the brow of a hill that the surface drainage was excellent, but it was not underdrained. The soil was clay loam, underlaid with hardpan at a depth of only five inches! The seed was sown June 12, 1905. The young plants prospered and passed the first winter safely. During 1906 three cuttings were made and a total yield of about six tons of cured hay obtained. The field was not seen by a Station representative during 1907, but the owner reports that it was again mown three times, the yield being about four tons of cured hay.

SOIL DEFICIENT IN HUMUS.

Many New York soils are greatly deficient in humus. This is a condition which militates against success in starting alfalfa. It may be remedied by plowing in clover or by the application of stable manure. Stable manure is exceedingly useful. As a rule, it should be plowed in the fall before seeding. If used as a top dressing immediately before sowing it must be thoroughly rotted to avoid the introduction of weeds which will surely make serious trouble.

SOIL DEFICIENT IN NODULE-FORMING BACTERIA.

It is a well known fact that alfalfa will not thrive unless the roots bear the so-called nodules.[11]

These are caused by bacteria, *Pseudomonas radicicola* (Beyer.) Moore.[11a] Some soils will not produce alfalfa because they are

[10] Stone (99, p. 7).

[11] The literature of this subject prior to 1903 has been collected by MacDougal (61) and Schneider (90), (91). See also Atkinson (2) and Jacobitz (49).

[11a] Recent investigations by de'Rossi (83*a*) indicate that the so-called bacteroids, and not *Pseudomonas radicicola*, are the cause of the nodules. Heretofore, the bacteroids have been regarded as an involution form of *Ps. radicicola*, but de'Rossi holds that they belong to a distinct species.

deficient in the nodule-forming bacteria. For several years it has been known that some of the alfalfa failures in New York are due to this cause and recent investigations by the Bacteriological Department of the Station enable us to make an estimate of the extent of such deficiency.[12] In 65 experimental fields a portion of each was artificially inoculated by spreading over it a small quantity of soil from an old alfalfa field. Satisfactory crops of alfalfa were obtained on the inoculated portion of 46 of these fields; whereas, on the uninoculated portion only 13 gave satisfactory crops. In other words, artificial inoculation increased the percentage of successes from 20 to 70. Since the experiments were distributed over 33 counties it would appear that they represent fairly well the conditions prevailing over the State as a whole. If so, at least 50 per ct. and perhaps as much as 75 per ct. of our soils are deficient in nodule bacteria.

One of the above-mentioned experiments showing beneficial effects from artificial inoculation was conducted by R. C. Colyer, Hicksville, Long Island. The experimental field contained about two acres. It was about twice as long as wide and nearly level. After plowing in the spring of 1906 the field was limed all over, shell lime being used at the rate of 75 bu. per acre. It was then planted with early potatoes. After the potato crop was harvested, during the last week in July, the land was plowed and harrowed. Three weeks later an application of commercial fertilizer, 500 lbs. per acre, was made and the land harrowed a second time. During the last week in August, 1906, the seed was sown at the rate of 30 lbs. per acre and harrowed in lightly. In order to test the effect of inoculation a strip along the west side of the field (about one-half acre) was treated with 140 lbs. of soil from the Station alfalfa field. It was sown broadcast after the alfalfa was up. The alfalfa came up well and went into the winter in good condition with no apparent difference between the inoculated and uninoculated portions of the field.

In the spring of 1907 there was nothing unusual at first but by the latter part of May there was considerable difference in color between the inoculated and uninoculated portions. During the early part of June the contrast in color steadily increased and became very marked. Up to this point the observations here reported were made by Mr. Colyer. On June 11 the senior author examined the experiment and observed the following: The difference in color

[12] Harding and Wilson (39).

and size of the plants was so striking that the boundary of the inoculated strip could be followed by the eye the whole length of the field. (See diagram on page 181.) On the inoculated strip there was a rank growth of dark green color. The plants were 17 to 24 inches high, most of them were robust and much branched, and they covered the ground completely. On the adjacent uninoculated portion of the field there was a light growth of golden yellow color. The plants were 12 to 17 inches high, slender, mostly unbranched and the ground among them was plainly visible. The yellow plants did not show any dead or spotted leaves — they were simply golden yellow throughout. However, this condition did not prevail over *all* of the uninoculated portion. On a strip about 50 ft. in width and extending from the south end about one-third of the distance across the field near the east side, the alfalfa was nearly as large and as good color as on the inoculated strip. A satisfactory explanation of this could not be found. This part of the field was a little lower than the rest. Scattered over the remainder of the uninoculated portion were occasional small clumps of thrifty, dark green plants which contrasted strongly with the yellow plants about them. Such clumps were especially numerous in a line extending from the low area above-mentioned to the north end of the field. This is shown in the diagram.

Upon making an examination of the roots it was learned that the dark green plants, wherever found, were well supplied with nodules which often occurred in conspicuous whitish clusters one-half inch or more in diameter; while the yellow plants, even when standing close beside green ones, appeared to be wholly devoid of nodules.

Mr. Colyer states that the first cutting was made July 1, when the alfalfa was commencing to bloom. On the inoculated strip (A) and the low area (C) there was a heavy yield of hay, but no weights were taken. The second cutting was made on August 9 and 13. On the latter date we made a second examination of the experiment. This time there was a fairly good crop of hay on the inoculated strip and the low area, while over the remainder of the field the plants were short and there were many bare spots. The contrast in color had now entirely disappeared. The whole field was of the normal green color. However, it was evident that many of the yellow plants had died. The nodules, also, had mostly disappeared. A few live, plump nodules were found and some of the clusters were still in evidence, but most of them were shriveled and dead. A severe drought prevailed at this time and the ground

was exceedingly dry. It should be stated, also, that over the whole field the plants were severely attacked by leaf spot (*Pseudopeziza medicaginis*) which caused a majority of the leaves to fall.

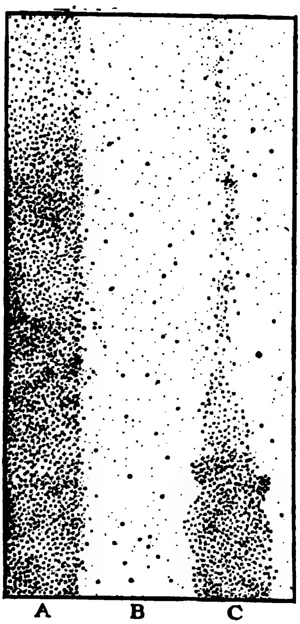

DIAGRAM OF THE HICKSVILLE ALFALFA SOIL INOCULATION EXPERIMENT.

Dark shading indicates good growth, as shown by large, dark green plants.

A — Half-acre strip artifically inoculated with soil.

B — Uninoculated.

C — Low area where alfalfa grew well without artificial inoculation.

Mr. Colyer reports that the third cutting in 1907 was made October 1 and that in the spring of 1908 the inoculated portion made a splendid growth, the plants standing 12 inches high by May 12.

In several other experiments the beneficial effects of inoculation were quite as marked as in this one and manifested themselves in a similar manner.

As the best method of supplying nodule bacteria, the Station advises the use of soil from a successful alfalfa field. It should be sown broadcast at the rate of 150 to 200 lbs. per acre. This is the method now most used in the State. The principal objection to it is the danger of introducing troublesome weeds and plant diseases. However, if proper precautions are taken the risk is slight. In New York no case of serious trouble from this source has come to our attention. Nevertheless, because of such danger, Moore[13] and others of the United States Department of Agriculture discourage the use of soil and recommend pure cultures instead. Con-

[13] Moore (67); Moore and Robinson (69); Woods (114), (115); Kellerman and Robinson (51), (52).

cerning this disagreement in recommendations we can only say that we doubt that the pure-culture method is yet sufficiently perfected so that it can be safely relied upon to produce the desired results.[14]

WINTER INJURY.

In New York, as elsewhere,[15] it is not uncommon for alfalfa to winterkill. Yet, where other conditions are favorable as, for example, in Onondaga County, fields last for many years. Spillman[16] cites a New York alfalfa field 45 years old. Coburn[17] says, "there is a field in New York which has been mown successively for over sixty years."

More or less injury occurs every winter. The winter of 1903–1904 in New York was the coldest since temperature records of the State Weather Bureau began in 1888 and alfalfa winter-killed to an unusual extent.[18] The ground froze deeply, there was much freezing and thawing during March and probably what was most disastrous of all, a thaw in February was followed by a sudden, hard freeze which left the ground covered with a thick coat of ice. On the Station farm an alfalfa field which had produced good crops for several years was completely killed out.

Winterkilling is brought about in different ways — by freezing of the roots, by heaving, and by smothering of the plants under ice and standing water. It is prevented chiefly by providing good surface and underdrainage, and by avoiding late cutting in order that the alfalfa may go into the winter with several inches growth to hold the snow. Top-dressing with stable manure in December is

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[14] Some recent papers bearing on this point are the following: Harding and Prucha (8); Kellerman and Beckwith (50); Harding (37); Moore (68); Stone (100); Prucha and Harding (81). See also those cited in footnote 13 and the following Experiment Station bulletins and reports: Cornell (N. Y.) Bul. 237; Ga. Bul. 71; Ky. Bul. 125; Mass. Rpt. 18: 77; Me. Bul. 126; N. C. Rpt. 30; Ohio Bul. 181; Okla. Bul. 68; Ontario (Can.) Agr. Coll. Buls. 148 and 164; Pa. Bul. 78; Tex. Bul. 83; Va. Bul. 159; W. Va. Bul. 105; Wis. Rpts. 22: 242 and 23: 281. See, also, Circ. 16, Office of the Secretary, U. S. Dept. Agr., Mar. 1906.

[15] Brand (6); Buffum (11); Moore and Stone (70); Wiancko (108); Watson (106); Wilson (111); Williams and Kyle (109).

[16] Spillman, W. J. Quoted by Coburn (15, p. 9).

[17] Coburn (15, p. 5).

[18] Stone (99) gives the mean temperature at Ithaca for each of the three winter months (December, January and February) from 1888 to 1904. He also discusses the winter killing of alfalfa in New York in 1904.

also useful. Winterkilling is most likely to occur during the first winter after seeding especially if the soil conditions are in any way unfavorable. It is possible that a part of the winterkilling of newly-seeded fields in New York is due to the use of southern-grown seed. Although there appear to be very few data on which to base an opinion, it is claimed by some that Arizona-grown seed will not succeed here. Wing[19] says, "Arizona seed if brought as far north as Buffalo will surely die out." Considerable Arizona seed has been used in the State. Alfalfa certainly varies much in hardiness. Brand[20] states that Peruvian alfalfa is completely lacking in hardiness in all northern localities. Until comparative tests have been made in New York it can not be stated from what region it is best to secure seed for use here. Coburn,[21] on theoretical grounds, advises Utah seed grown without irrigation.

FAILURE OF THE SEED CROP.

It is of little use to attempt to produce alfalfa seed in New York. A few years ago F. H. Stillwell, Manlius, N. Y., grew about eight bushels of alfalfa seed, four bushels of which came from a single acre. This is the only success known to us. On the Station grounds several unsuccessful attempts have been made to obtain seed from Turkestan alfalfa and the common sorts, sown broadcast and also in drills. However, plants missed by the mower on the margins of fields sometimes seed sparingly. Probably, climate conditions are in some way responsible for the failure of alfalfa to seed in New York, but the exact manner in which the trouble is brought about is not clear.

VIABILITY OF THE SEED.

Concerning the viability of alfalfa seed in New York, definite statements can not be made. The writers have made few germination tests. However, judging from the appearance of samples sent in by farmers and seedsmen we are of the opinion that the alfalfa seed sold in New York is frequently rather low in viability.[22] The Station can not undertake to make germination tests, but farmers should make such tests for themselves. With some experience one may determine, approximately, the viability of alfalfa seed by its color and plumpness, but it is generally advisable to

[19] Wing (113). [20] Brand (6). [21] Coburn (15, pp. 28–29).

[22] The standard germination for alfalfa seed is 85 to 90 per ct. (U. S. Dept. Agr. Yearbook for 1896: 624).

make germination tests.[23] Usually, plump, bright, greenish-yellow seed may be depended upon to germinate well. Brown seed should be avoided. Brownness is an indication of age. It is hastened by exposure to light. Shriveled, dark-brown seeds are usually dead. Plump brown seeds, on the contrary, may germinate fairly well, for plump seeds retain their viability for several years. Of 100 plump brown seeds selected by the writers from a sample of unknown age, 90 germinated. In tests made by Headden[24] a sample of prime seed 12 years old showed a germination of 93.66 per ct. while another sample 16 years old gave 63 per ct.

In this connection it is interesting to note that while, according to Headden,[25] 70,000 to 650,000 plants per acre constitute a good stand of alfalfa it is considered necessary to sow from 10 to 100 times that many seeds per acre. From 20 to 30 lbs. of seed per acre is the quantity recommended in New York, the majority of experts favoring the larger amount. The number of seeds contained in a pound of alfalfa is variously stated by different investigators. Probably, the figures given by Nobbe[26] are as reliable as any. He tested 47 samples of commercial seed in Germany and found the average number of seeds per pound to be 225,014. Our own work on this subject consists of an examination of six samples of prime seed offered for sale at different places in New York. Preparation of the samples for counting consisted in shaking them well in the 20 x 20 mesh sieve recommended for removing dodder (see page 194) and afterward removing by hand such impurities as would not pass through the sieve. The results of the counts were as follows:

Sample	No.	1	5	gms.	pure	seed	contained	2272	seeds	=206115	per	lb.
"	"	2	5	"	"	"	"	2281	"	=206932	"	"
"	"	3	5	"	"	"	"	2316	"	=210106	"	"
"	"	4	10	"	"	"	"	4935	"	=223851	"	"
"	"	5	10	"	"	"	"	4938	"	=223987	"	"
"	"	6	10	"	"	"	"	5166	"	=234329	"	"

Average of six samples, 217,545 seeds per pound.

From these figures it will be seen that in 30 lbs. of prime alfalfa seed there are over 6,000,000 individual seeds. Either the seed

[23] On this point see Roberts and Freeman (83, p. 61).
[24] Headden (41). [25] Headden (40, p. 40).
[26] Nobbe (73, p. 501).

sown is low in viability or else the mortality of the seedlings is extremely high.

IMPURE AND ADULTERATED SEED.

New York farmers experience considerable difficulty in obtaining pure alfalfa seed. It being next to impossible to produce alfalfa seed in New York, all of the seed used must be purchased from seed dealers. Frequently, the Station is asked to recommend some seedsmen who may be relied upon to furnish good seed. Such requests are refused because it is the established policy of the Station to avoid advertising anyone's business. Farmers are advised to buy by sample and not to sow alfalfa seed until an expert has examined it for dodder and other troublesome weeds and for evidence of adulteration. For residents of New York, the Station makes such examinations free of charge.

IMPURITIES.

Between November 20, 1906, and August 15, 1908, the Station analyzed 548 samples of alfalfa seed sent in by farmers and seedsmen from various parts of the State. Since these samples were grown in many different parts of the world it is to be expected that they would contain many different kinds of weed seeds and such was found to be the case. Several of the weed seeds we were unable to identify. One of these unknowns, found in 37 samples, was sent to the Seed Laboratory of the United States Department of Agriculture for identification. Mr. Edgar Brown, Botanist in Charge, informs us that the seeds are of a species of Centaurea, which is common in Asia Minor, and that they probably come to us only in the seed of Turkestan alfalfa. Thus it is sometimes possible to determine where seed was grown by the weed seeds it contains.

Usually, it is the character of the impurities rather than their quantity which makes them objectionable. The most objectionable impurity of all is dodder seed. So little as one dodder seed per pound renders alfalfa seed unsafe for use. Dodder often makes serious trouble in alfalfa fields and no chances should be taken with it. Of the 548 samples analyzed, 126, or 23 per ct., contained more or less dodder. In 122 of the infested samples the number of dod-

der seeds per pound was determined. The numbers, given in the order of their size, are as follows:

2	8	16	25	38	58	99	162	270	892
2	11	16	26	39	60	100	174	273	972
2	11	17	27	40	62	100	176	278	1123
3	12	17	28	44	62	102	182	309	8652
4	12	18	32	44	65	105	189	320	22996
4	13	20	33	45	65	108	190	321	
5	14	21	34	46	65	119	192	378	
6	14	21	34	47	67	127	194	489	
6	14	21	34	52	68	129	197	645	
7	15	22	35	53	73	138	198	672	
7	15	22	36	56	76	141	227	735	
8	16	23	37	57	77	143	232	744	
8	16	23	37	57	82	156	234	870	

Several different species of dodder infest alfalfa, but how many of them are represented in the above-mentioned samples is not known. The identification of the different species by their seed characters being somewhat difficult, the writers have not attempted it. It appears that for all practical purposes it makes little difference to what species the dodder belongs except that the seed of some species, being larger than that of others, is more difficult to remove by sifting. (See page 194.) Accordingly, the writers place them all in two classes, small-seeded dodders and large-seeded dodders[27]. (See Plate XVII, figs. 3 and 4.) In the samples analyzed, the small-seeded kinds of dodder greatly predominated.

Most of the dodder-infested samples belonged to the poorer grades of seed, but some of them were decidedly high grade in all respects except that they contained dodder. Seed may be of good color, high purity and high-priced yet contain enough dodder to make it unfit for use. Even the so-called recleaned seed is not entirely reliable as regards freedom from dodder.

However, the use of dodder-infested seed does not necessarily result in a dodder-infested crop. Probably, the great majority of dodder seeds fail to make plants. In the spring of 1906 the writers

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[27] Hillman (46) distinguishes five principal species of dodder occurring in alfalfa seed; viz., *Cuscuta epithymum* Murr. (clover dodder), *C. planiflora* Ten. (small-seeded alfalfa dodder), *C. arvensis* Beyrich (field dodder), *C. indecora* Choisy (large-seeded alfalfa dodder) and *C. racemosa chileana* Engelm. (Chilean dodder). The first two have small seeds, the last three, large ones. Hence, the term "small-seeded dodders" as used by the writers includes Hillman's first two species while the other three are classed as "large-seeded dodders."

sowed three twentieth-acre plats with dodder-infested alfalfa seed from three different sources. The exact number of dodder seeds applied to Plats I and II is not known, but the seed used was taken from lots analyzing, respectively, 105 and 360 dodder seeds per pound. Since one and one-half pounds of seed were sown on each plat, it is likely that Plat I received about 157 and Plat II 540 dodder seeds. In both cases the dodder was one of the small-seeded kinds, *Cuscuta epithymum* Murr. Plat III received seed containing (by actual count) 120 seeds of one of the large-seeded dodders. A fourth plat of the same size was sown, at the same time, with red clover seed containing 100 dodder seeds from the same source as those used on Plat III.

A good stand of alfalfa and clover was obtained on all four plats, but there was never any evidence of dodder. Each of the plats was carefully examined several times during 1906 and 1907 without the discovery of a single dodder plant. Concerning the viability of the dodder seed at time of sowing nothing is known except that a part, at least, of the seed used on Plat II must have been viable since some dodder from the same lot of seed germinated in March, 1907.

Narrow-leaved plantain (*Plantago lanceolata* L.), also called English plantain and buckhorn and generally regarded as a troublesome weed, was found to be a very common impurity. Thirty-six and one-half per ct. of the samples contained more or less of it. The actual amount was determined in only fifteen of the worst-infested samples in which the numbers of seeds per pound of alfalfa seed were as follows: 154, 224, 246, 332, 348, 453, 477, 513, 586, 605, 627, 756, 944, 1451 and 1457.

Yellow foxtail (*Setaria glauca* (L.) Beauv.) and green foxtail (*Setaria viridis* (L.) Beauv.) were found in a large percentage of the samples. Although these are troublesome weeds they are so universally distributed that their presence in alfalfa seed is not considered to be of any particular importance. Wild carrot (*Daucus carota* L.) also occurred in a considerable number of the samples, and Russian thistle (*Salsola kali* L. var *tenuifolia* G. F. W. Mey), was found in 78 of the 548 samples examined.

Besides a large number of unimportant weeds some kinds of which occurred in many samples, the following troublesome weeds were found occasionally: Curled dock (*Rumex crispus* L.), crab grass (*Digitaria sanguinalis* (L.) Scop.), Canada thistle (*Cirsium*

arvense (L.) Scop.), chicory (*Cichorium intybus* L.), charlock (*Brassica arvensis* (L.) Ktze.), black mustard (*Brassica nigra* (L.) Koch.) and quack grass (*Agropyron repens* (L.) Beauv.).

The question naturally arises, how great is the risk incurred in sowing impure alfalfa seed and what are the most dangerous impurities? As stated above, the risk on dodder is certainly large. The damage done by this pest is discussed more fully on page 197. Narrow-leaved plantain and wild carrot are troublesome weeds, but the great majority of New York farms are already infested with them so that the sowing of a few additional seeds with alfalfa seed can do no great harm. However, there are some careful farmers who are making strenuous efforts to keep their farms free from these weeds. To such persons, even a small amount of narrow-leaved plantain or wild carrot in alfalfa seed would be objectionable. Canada thistle, curled dock, mustard and charlock are all very bad weeds and few persons would care to use any seed containing them. Fortunately, they do not occur in alfalfa seed very frequently; besides, it is probable that all of them find much difficulty in establishing themselves in alfalfa fields. Further discussion of this subject will be found on page 214.

The danger from weeds is often greatly overestimated. The Russian thistle is a conspicuous example. About fifteen years ago much ado was made over the Russian thistle and several of the experiment stations published sensational bulletins on the subject. Subsequent events have shown the weed to be quite unimportant.[28] Certainly, New York farmers have nothing to fear from it. Although seeds of Russian thistle must have been sown with alfalfa seed many times the plant is almost unknown here. There have come to our attention only two instances in which Russian thistle has appeared in alfalfa fields in New York. Both of these occurred in 1908 — one near Geneva and the other at Halls Corners. We have not seen it growing elsewhere in the State. However, Peck[29] records its occurrence near Rochester and Prof. W. W. Rowlee of Cornell University informs us that it is quite abundant around the salt sheds and on the waste of the Solvay Process Co., at Syracuse.

ADULTERATION.

Alfalfa seed is sometimes adulterated. Each year, during June, the Station receives almost every day one or more specimens of a

[28] Bessey (5).
[29] Peck (75).

clover-like plant with small yellow blossoms. Usually, the specimens are accompanied by a statement to the effect that plants of this kind constitute one-half or more of the herbage in fields sown the summer before with what was supposed to be alfalfa seed. The sender of the specimens is informed that the strange plant is yellow trefoil (*Medicago lupulina* L.)[30] the seed of which closely resembles alfalfa seed and being much cheaper than alfalfa is used to adulterate it.[31] (See Plate XVII, figs. 2 and 5.) He has sown adulterated seed.

Between 1901 and 1905 trouble of this kind became so common as to attract general attention. Farmers became more cautious in purchasing alfalfa seed and began sending samples to the Experiment Station for analysis. Then Congress helped out by directing the Secretary of Agriculture to obtain in the open market samples of alfalfa and certain other seeds and if any are found to be adulterated or misbranded to publish the results of the tests together with the names of the persons by whom the seeds were offered for sale.[32] Moreover, in a few cases the matter was taken into the courts and farmers collected damages from seed dealers who had sold them adulterated seed.

It appears that these things have had a tendency to discourage the sale of adulterated alfalfa seed in New York. During the past two or three years the situation has improved considerably. Of the 548 samples of alfalfa seed analyzed by the Station between November 20, 1906, and August 15, 1908, only ten showed evidence of adulteration and none of these were heavily adulterated. One of the adulterated samples contained 9 per ct. of sweet clover (*Melilotus alba* Desr.) while in the other nine the adulterant was yellow trefoil which was used to the extent of 6 per ct. in two samples, about 7 per ct. in four samples, 8.4 per ct. in one, 9 per ct. in one, and 10 per ct. in the remaining one.

Besides yellow trefoil and sweet clover, two species of bur clover (*Medicago hispida* Gaertn. and *Medicago arabica* Huds.) are used to adulterate alfalfa seed. Adulterated samples frequently contain both yellow trefoil and bur clover.[33] In New York, there have come to our attention only four cases of adulteration with bur

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[30] The nature and habits of yellow trefoil are described more fully on page

[31] Brown (9); Roberts and Freeman (83); Galloway (35), (36).

[32] Two circulars dealing with alfalfa seed have been published under this act. See Galloway (35), (36).

[33] Galloway (35), (36).

clover. One of these was a quantity of alfalfa seed purchased by the Station in Geneva in 1904. It was heavily adulterated with yellow trefoil and also contained a considerable amount of the two species of bur clover. Some of the seed was sown and the resulting plants of bur clover identified as *Medicago hispida* and *M. arabica*. In 1908 a sample from Oswego contained nine per ct. of yellow trefoil and two per ct. of bur clover. A sample of alfalfa seed sent to the Station from Canandaigua in 1904 showed 30 per ct. yellow trefoil and 4 per ct. bur clover. Another sample from Canandaigua in 1905 contained 44.4 per ct. yellow trefoil and 3.9 per ct. bur clover. This last sample has a court history which it may be well to relate since it has a bearing on the responsibility of seed dealers for damages resulting from the use of adulterated seed.

In June, 1904, G. M. Depew of Canandaigua, N. Y., sowed a 15-acre field with alfalfa using 30 pounds of seed per acre. Two-thirds of the field was sown with seed purchased from the Peck Hardware Co., Canandaigua, N. Y., and the remaining five acres with seed from another seed dealer. In the fall of 1904 the stand of alfalfa appeared good, but in the latter part of May, 1905, a part of the plants supposed to be alfalfa produced yellow blossoms. Specimens were sent to the Experiment Station where they were identified as yellow trefoil, *Medicago lupulina*. In a letter accompanying the specimens Mr. Depew stated that the yellow-flowered plant constituted one-half the crop. We advised him to plow up the field and reseed it. This he did about the middle of July, 1905. He then sent to the Station a sample of the seed left over from sowing the last five acres. An analysis of this seed showed it to contain 44.4 per ct. yellow trefoil and 3.9 per ct. bur clover besides some minor impurities and dodder at the rate of 114 seeds per pound. Upon being threatened with a suit for damages the dealer who sold this seed settled. The Peck Hardware Co., however, refused to settle and was sued for damages as follows:

Loss of one year's crop of alfalfa on ten acres...	$700 00
Plowing and fitting ten acres for reseeding......	80 00
Alfalfa seed to sow ten acres..................	42 00
Total	$822 00

The case was tried in the Ontario County Court at Canandaigua in June, 1906. As to whether the seed had been bought upon an

express guaranty, the evidence was conflicting; but there was positive evidence that it had been represented to be "good alfalfa seed." In charging the jury the Judge stated that there is such a thing as an *implied* guaranty; also, if seed is sold as alfalfa seed there is an implied guaranty that it *is* alfalfa seed and in case it proves to be wholly or in large proportion some other kind of seed the seller may be held liable for damages. No mention was made of the so-called "non-warranty clause" and it appears not to have figured in the case. None of the seed bought from the Peck Hardware Co. was in evidence as all of it had been sown. Proof of the existence of yellow trefoil in the Peck seed rested chiefly upon the testimony of several witnesses that the portion of the field sown with the Peck seed showed yellow blossoms the same as the five acres which was sown with the other seed shown by analysis to contain 44.4 per ct. yellow trefoil. As to the percentage of trefoil plants in the field, the testimony of different witnesses varied greatly. One said it was only 9 per ct. while others placed it at 50 to 90 per ct. Several witnesses testified to the frequent occurrence of trefoil along the highways in the vicinity of the Depew farm and the defense endeavored to show that the trefoil in the Depew field may have come from seed already in the soil[34] or from wild plants in the vicinity. Two witnesses testified to instances in which alfalfa fields showing much trefoil in the second season after seeding were practically free from trefoil in the third season. The defense claimed that the plowing of the field was unwarranted by the circumstances. The presence of growing dodder in the field was proven and counsel for the plaintiff pointed out that this was an additional reason for plowing up the field.

The jury rendered a verdict for the plaintiff in the sum of $377.42 with costs. The case was then carried up to the Appellate Court where the plaintiff won again. Finally, it was taken to the Court of Appeals where it has not yet been passed upon at this writing (November 14, 1908).

ANALYSES.

For residents of New York, the Station makes purity tests of alfalfa and other seeds free of charge. Seed dealers should learn to recognize dodder and the other principal impurities and adulter-

[34] This is unlikely since the land grew oats in 1902 and corn in 1903 and no manure was applied in 1904 the season in which the alfalfa was sown.

ants of alfalfa seed,[35] but for farmers this is scarcely worth while. Most farmers will find it safer and more satisfactory to rely on tests made by experts at the Experiment Station or in the United States Department of Agriculture. An analysis made by an expert is the farmer's chief safeguard against impure and adulterated seed. Samples of alfalfa seed for analysis should contain at least two ounces and should be taken in such manner as to represent fairly the lot of seed to be tested.[36] If the seed is in bags the sample should contain some seed from each bag and in all cases a portion of it should be taken from the bottoms of the bags. When alfalfa seed containing dodder seeds is shipped in bags in an upright position the dodder seeds, being smaller than the alfalfa seeds, tend to settle to the bottoms of the bags. Samples should bear the name and address of the sender. The postal rate on seeds is one cent an ounce.

Many of the samples received at the Station are entirely too small for a dependable analysis as regards dodder. The samples sent out by seedsmen are usually too small. A majority of the 548 samples reported upon in this bulletin contained less than one ounce. Had all the samples been of proper size it is likely that the number found to be infested with dodder would have been larger.

A sample from Moira, N. Y., containing only 2 grams was free from dodder. Upon being informed that the sample was too small, the sender forwarded another 20-gram sample of the same seed. This contained 22 dodder seeds which is at the rate of 499 per pound.

A Canandaigua farmer brought to the Station a good-sized sample taken from the top of a bag of seed. It was entirely free from dodder. A few days later he brought another sample from the same bag but obtained by thrusting his hand deeply into the bag. This sample contained dodder at the rate of 20 seeds per pound.

A farmer at Delhi, N. Y., sent a sample (5.3 grams) which was found to be free from dodder. Upon receipt of the Station report on the sample he purchased and sowed some of the lot of seed from which, supposedly, the sample had been taken. However, the seed dealer was in doubt as to which bag the sample had been taken

[35] Some bulletins especially useful for this purpose are the following: Hillman (44), (45), (46); Brown (9); Roberts and Freeman (83).

[36] Detailed directions for taking samples are given in, Rules and Apparatus for Seed Testing. U. S. Depart. Agr. Office of Experiment Stations. Circ. 34 (Revised). 1906.

from and a mistake may have been made. Anyway, the crop was practically ruined by dodder during the first season.

These examples show the importance of using proper samples for analysis; also, that absolute confidence should not be placed in an analysis. As an additional precaution against dodder the writers advise the sifting of alfalfa seed as described under the next heading.

SIFTING SEEDS TO REMOVE DODDER.

Trouble with dodder in alfalfa fields is usually due to the use of dodder-infested alfalfa seed. Since much of the alfalfa seed on the market in New York is more or less infested with dodder it is often difficult to obtain dodder-free seed. The statements of seed dealers should not be relied upon. Most of the alfalfa seed in this State is handled by hardware merchants and small seed dealers who, themselves, do not know dodder seed. As dodder seeds are much smaller than those of alfalfa they may be easily overlooked. Good-looking seed, otherwise clean, may be badly infested with dodder. Even so small an amount as one dodder seed per pound makes alfalfa seed dangerous to sow until properly cleaned. Farmers are advised to protect themselves against dodder by sowing no alfalfa seed until it has been pronounced dodder-free by a seed expert or else sifted as directed below. The safest method is to have the seed both analyzed and sifted.

The idea that alfalfa seed may be freed from dodder is not a new one. But prior to the appearance (in January, 1907) of Circular No. 8 of this Station[87] the information on the subject available to New York farmers was too meager and indefinite to be of any practical value. It is not sufficient to state merely (as has sometimes been done)[88] that a 20-mesh sieve should be used. It is necessary to know, also, the size of the wire, where sieves of the proper kind can be obtained and how they are to be used. To the uninitiated it may seem that the size of the wire is unimportant, but, in practice, it makes all the difference between success and failure. With a given mesh, the larger the wire the smaller will be the openings. It is desirable that the openings shall be as large as possible without permitting the passage of an unduly large amount of alfalfa. After several experiments on sifting dodder-infested seed with sieves of various kinds the writers reached the

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[87] Stewart and French (98).

[88] Hillman (43, p. 8; 45, p. 10); Selby and Hicks (93). More explicit directions are given by Hillman (46, p. 20).

conclusion that the proper sieve for the purpose is one made of 20 x 20 mesh steel- or iron-wire cloth, the wire being No. 34 on the Washburn & Moen gauge. (If a brass- or copper-wire sieve is used it should be 20 x 20 mesh No. 33 wire on the Old English gauge.)[39] Unfortunately, ready-made sieves of this kind are not readily obtainable. Also, it is difficult to get them made, because few hardware dealers carry in stock the proper kind of wire cloth. Accordingly, the Station had a quantity of the 20 x 20 mesh No. 34 steel-wire cloth made to order and placed it in the hands of Dorchester & Rose, Geneva, N. Y., who offered in for sale during 1907. The original lot has been all sold, now, but Dorchester & Rose have had some more made on their own account and expect, hereafter, to keep it for sale at twenty cents per square foot, post-paid.

A foot-square piece of this wire cloth tacked over a light wooden frame twelve inches square by three inches deep makes a cheap, serviceable sieve for sifting alfalfa seed (see Plate XVI).

With such a sieve a man should be able to clean from three to seven bushels of seed per day. One-fourth to one-half pound of seed should be put into the sieve at a time and vigorously shaken during one-half minute. In order that the work may be uniformly thorough the operator should use a cup holding not over one-half pound thereby making it impossible to get too large a quantity at one time. A watch should be kept constantly in sight and no more than two batches of seed should be sifted in one minute. If the seed is known to contain but little dodder, one sifting will do; but when there is much dodder and particularly if the dodder is one of the large-seeded kinds, two siftings, both made strictly in accordance with the above directions, are recommended.

Our experiments and observations indicate that by the above method most alfalfa seed on the market in this State may be made practically free from dodder and safe to sow. Of course it is ad-

[39] No. 34 brass wire is not of the same size as No. 34 steel wire. In 1900 the Wire Cloth Manufacturers' Association adopted the Washburn and Moen gauge for all steel- and iron-wire cloth and the Old English gauge for all brass and copper-wire cloth. On the Washburn and Moen gauge No. 34 wire has a diameter of .0104 inches. Hence, in 20x20 mesh No. 34 steel-wire cloth the actual size of the openings is .0396 in. each way. On the Old English gauge, No. 34 wire has a diameter of .0095 in. which makes the size of the openings in 20x20 mesh No. 34 brass-cloth .0405 in. each way. This is too large. No. 33 brass wire, which has a diameter of 0.1025 in. and gives openings .03975 in. wide, more nearly meets the standard requirements.

visable to begin with seed as nearly free from dodder as can be conveniently obtained. If a sample of the seed has been examined at the Experiment Station the owner has been informed as to whether the dodder in it is of the small-seeded or large-seeded kind and he should manage the sifting accordingly. Occasionally, samples are found in which some of the dodder seeds are so large that they will no pass through the sieve. Fourteen cases of this kind were found among the 126 dodder-infested samples examined at the Station. Such seed should not be used.

Since the farmer has no means of determining whether he is removing all of the dodder it is absolutely necessary for him to follow directions closely. Care should be taken to secure the right kind of sieve. In purchasing sieves or wire cloth for making sieves it should be seen to that they are actually 20 x 20 mesh. This may be determined by placing a rule on the sieve and counting the number of meshes to the inch. Also, the wire must not be coarse. The Station will furnish small samples of the proper kind of wire cloth free upon request.

The quantity of siftings varies from one to five pounds per bushel according to the original cleanliness of the seed and the thoroughness of sifting. Besides dodder, various other small weed seeds, broken seeds and dirt, as well as some of the smaller alfalfa seeds, also pass through the sieve. Probably, most of the alfalfa seeds which pass through the sieve are somewhat inferior in quality. Small, shriveled seeds are not likely to make as strong plants as are large plump seeds. However, it appears that the difference is not as great as might be supposed. Once, the writers put this to the test. Two lots of seed were thoroughly sifted according to the directions given above. Then the cleaned seed and screenings (with dodder removed) were sown side by side under parallel conditions. The experiment was continued only two years, but during this time there was no observable difference between the plats sown with cleaned seed and those sown with screenings. Still, it is believed that little if any real loss is sustained through the rejection of the screenings. If the seed contained dodder the quantity of this pest in the screenings will probably be so great as to ruin the crop. Even when the seed has been analyzed and reported free from dodder it is generally advisable to sift it as an additional precaution. In such cases the screenings might be sown by themselves in one corner of the field so that should dodder appear it could be stamped out with a minimum amount of loss.

In experimenting with some samples of alfalfa seed infested with narrow-leaved plantain (*Plantago lanceolata*) it was observed that the sifting for dodder reduced considerably the percentage of plantain.[39a] The results of three experiments with three different lots of seed are shown in the following table:

TABLE I.—SHOWING RESULTS OF SIFTING ALFALFA SEED TO REMOVE SEED OF NARROW-LEAVED PLANTAIN (*Plantago lanceolata*).

Experiment.	Number of *P. lanceolata* seeds per lb. before sifting.	1st Sifting.		2d Sifting.		Total.	
		Number seeds per lb. removed.	Percentage removed.	Number seeds per lb. removed.	Percentage removed.	Number seeds per lb. removed.	Percentage removed.
I......	416	128	30.76	16	3.84	144	34.61
II......	544	160	29.4	32	5.88	192	35.29
III......	543	154	28.36	85	15.65	239	44.01

It is to be hoped, that in the future, seed dealers will take more care to remove dodder from their alfalfa seed. Farmers should aid the movement for better seeds by refusing their patronage to firms offering adulterated and dodder-infested seed for sale. Some seed dealers advertise alfalfa seed sifted according to the method recommended by the Experiment Station. This is well, but we would caution farmers against placing implicit confidence in such seed. Samples should be submitted to the Station for analysis just the same as in other cases. The sifting may not have been done properly. In the spring of 1907 a Geneva farmer brought to the Station 90 lbs. of alfalfa seed which he had purchased with the understanding that it had been thoroughly sifted as directed by the Station. Resifting this seed brought to light 660 seeds of one of the small-seeded kinds of dodder.

DODDER.

BRIEF GENERAL STATEMENT.

Dodder is a yellowish, thread-like, twining plant which is very troublesome in alfalfa fields. It usually appears in circular spots three to thirty or more feet in diameter. At the center of the spot

[39a] For removal of plantain seed from alfalfa seed, see Shaw (Bur. Plant. Indus. Circ. No. 2).

PLATE XVI.—TOOLS REQUIRED FOR SIFTING ALFALFA SEED TO REMOVE DODDER SEED.

1, Home-made sieve 12 in. square by 3 in. deep; 2, 20 x mesh wire-cloth made of No. 34 steel wire.

(Natural size.)

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PLATE XVII.— DODDER, ALFALFA AND YELLOW TREFOIL.

1, Alfalfa infested with dodder (*Cuscuta epithymum*) which is in bloom; 2, alfalfa seeds; 3, seeds of large-seeded dodder; 4, seeds of small-seeded dodder; 5, yellow trefoil seeds.

(All natural size.)

the alfalfa is mostly killed out while around the margin the ground is covered with a tangled mat of yellow threads which twine closely about the stems of the alfalfa plants and slowly strangle them. The spots increase in size from year to year. Many alfalfa fields have been completely ruined by dodder, sometimes during the first season after sowing, but more commonly in the second or third season. In New York, it is not often injurious to other crops (except red clover), but once established in an alfalfa field it is very difficult to eradicate without killing the alfalfa.

Dodder produces clusters of small white flowers, also seeds (see Plate XVII), but is leafless and has no connection with the soil except during the seeding stage. It is a parasite, deriving all its nourishment from the host plant about which it twines. The dodder infesting alfalfa in New York is probably of two or more kinds closely similar in appearance and producing similar effects. The kind of dodder most abundant in New York (*Cuscuta epithymum*) does not commonly seed here. It is carried over from one season to the next by means of the yellow threads which live over winter around the crowns of the plants (see page 203). Since trouble with dodder generally originates in the use of dodder-infested alfalfa seed it may be easily prevented by sowing only pure seed (see page 193). Frequent mowing will not kill dodder. It can not be combated successfully with sprays. Close pasturing is not practical. Heavy mulching with coarse manure and the application of strong chemicals such as arsenite of soda, crude carbolic acid and common salt are methods having some merit. Digging over the spots is effective, but expensive and not practicable in stony soil. In most cases the most satisfactory method is to burn over the infested spots using kerosene and dry hay to insure a hot fire which will kill the alfalfa as well as the dodder. This applies where the spots are not very numerous. Badly infested fields should be plowed up. In New York plowing generally eradicates dodder promptly so that, usually, infested fields may be reseeded at once with safety.

IMPORTANCE.

In New York, dodder is a really serious alfalfa pest, but it is outranked in importance by weeds and by leaf spot (*Pseudopeziza medicaginis*). Also, certain uncongenial soil conditions such as acidity, wetness and deficiency in nodule-forming bacteria, are more important. The notoriety attained by dodder is largely due to the plant's strange appearance which attracts attention to it. It is true,

however, that many farmers have had more or less trouble with dodder. Some fields have been ruined by it the first season, but in the majority of cases the greater part of the damage is done during the second and third seasons after sowing. Sometimes it is quite destructive in the second season where it was not observed at all during the first season. It is most conspicuous in the second and third cuttings.

Although dodder-infested hay is not refused by cattle it appears that they do not entirely relish it. There is no evidence that dodder is in any way injurious to cattle or other animals.

APPEARANCE OF INFESTED FIELDS.

The alfalfa is killed out in spots which vary much in size and shape. Spots resulting from a single infection are generally circular and rarely attain a diameter of more than 5 or 6 feet during the first season. Usually, they increase in size from year to year, ultimately reaching a diameter of 30 feet or more. In some spots the dodder dies out and may be said to have become extinct. By the coalescence of two or more spots large bare areas of irregular shape are formed. On the interior of the spots there remain a few scattered alfalfa plants which, somehow, escaped destruction by the dodder, but the ground is occupied chiefly by weeds.

Dodder-infested spots are especially conspicuous during the first week in May, owing to the fact that the alfalfa starts into growth sooner than the weeds on the interior of the spots. The dodder, however, is but little in evidence at this time. Its presence is revealed only by careful search. Later (from about June 10 on) it becomes conspicuous as a tangled mass of yellow threads which twine closely about the alfalfa plants around the margin of the spot. Not infrequently the dodder mats are so dense that they impede the progress of the mowing machine. Little or no dodder is found in the interior of the spots,—only around the margins.

SPECIES AND HOST PLANTS.

According to Engler and Prantl[40] there are 90 species of Cuscuta, the genus to which the dodders belong. All are parasites, but only a few of them are injurious to alfalfa. Just how many species of Cuscuta may attack alfalfa it is difficult to say. Hillman[41] gives

[40] Engler u. Prantl (28).
[41] Hillman (46).

five species the seeds of which occur in alfalfa seed; viz., *Cuscuta epithymum* Murr., *C. planiflora* Ten., *C. arvensis* Beyrich, *C. indecora* Choisy and *C. racemosa chileana* Engelm. Doubtless, seeds of all these species have been sown with alfalfa seed in New York and plants of all of them may exist here. Our field observations have not been sufficiently numerous to enable us to make a positive statement on this point. The problem is somewhat difficult owing to the fact that, in this State dodder in alfalfa fields flowers sparingly, and without either the flowers or seeds it is impossible to determine the species with accuracy. All of the flowering specimens examined by us have proven to be *Cuscuta epithymum* Murr. It is likely that this species is by far the most common one in New York alfalfa fields. It is also of frequent occurrence in clover fields here.

The color of dodder threads varies from yellow to red. On certain alfalfa plants or on certain spots all of the dodder threads may be yellow while on other plants or other spots they are all decidedly reddish. These differences in color are so marked, sometimes, as to suggest the idea that yellow-threaded dodder and red-threaded dodder may be two different species, but the writers have been unable to convince themselves that such is the case. Specimens with only yellow threads and others with only reddish threads have all shown themselves to be *Cuscuta epithymum* when they have produced flowers.

The dodders which attack alfalfa are capable of thriving, for a time at least, on some other plants; but New York farmers need have no fear of serious trouble with dodder in any crops excepting alfalfa and clover. It is a common thing for alfalfa dodder to twine around such weeds as occur on the infested spots, particularly ox-eye daisy (*Chrysanthemum leucanthenum* L.), dandelion (*Taraxacum officinale* Weber), and fleabane (*Erigeron annuus* (L.) Pers.). By means of its haustoria the dodder fastens onto these weeds quite as firmly as on alfalfa. On dandelion and fleabane it frequently lives over winter. Yet it appears to do the weeds no serious harm and infests them only when they are mixed with alfalfa or clover.

DODDER SEEDLINGS.

The following statements about seedlings are based upon observations made by the writers on seedlings of *Cuscuta epithymum* grown in the Station greenhouse.

Alfalfa seeds and dodder seeds sown together in boxes of earth

germinate at about the same time. Apparently, conditions favorable to the germination and growth of alfalfa are also favorable to dodder. The dodder seedlings are slender, unbranched threads, yellowish toward the tip and lighter colored below. (See Plate XVIII.) At first they stand upright, attaining a height of about an inch. Frequently, the tip is bent over to one side. If the dodder seedling comes in contact with an alfalfa seedling it twines around it and fastens onto it by means of haustoria. Then the lower portion of the seedling withers and connection with the soil is severed. (See Plate XVIII, fig. 2.) Unless the seedling comes in contact with some congenial host plant it lives only a few days. It soon becomes decumbent then commences to wither in the lower portion. Almost invariably seedlings become brown and shriveled at the surface of the soil while their tips are yet turgid and of normal yellow color. Dodder seedlings have no roots. Ten seedlings which had reached the limit of their growth and commenced to wither gave the following measurements respectively: 16, 17, 20, 20, 20, 20.5, 20.5, 22.5, 25 and 25 millimeters. On another occasion a seedling was found which measured 31 mm. in length. The writers have observed nothing indicating that dodder seedlings are attracted by alfalfa. It seems that contact is brought about purely by accident. In the field, the beating of the rain is probably one of the most important factors in bringing the dodder seedlings into contact with the host plant. As soon as the dodder has established itself on the alfalfa plant and begins to draw nourishment from it, the dodder threads become much larger in diameter and increase in length rapidly. The plant attacked soon stops growing and then gradually dies.

PROPAGATION AND DISSEMINATION.

Where alfalfa seed is grown, dodder produces seeds which, in threshing, became mingled with the alfalfa seed. Through the use of such alfalfa seed dodder is disseminated far and wide. It is in this way, mainly, that New York alfalfa fields become infested with dodder. Impure seed is at the bottom of nearly all of the trouble. The original dodder spots increase in size from year to year and new spots appear occasionally, but dodder does not spread rapidly like most weeds. It may exist for years in one corner of a field without showing in other parts of it and it rarely spreads to neighboring fields.

One reason why dodder does not spread more rapidly is that it does not commonly produce seed here. In many infested fields no

flowers can be found at any time during the season. In others, flowers may be abundant on certain spots and absent from others. Besides, many of the flowers fail to produce seeds. Why this is so we do not know. It can not be attributed to the frequent mowing of the alfalfa, because *Cuscuta epithymum*, at least, may produce flowers and seeds low down on the plants below the reach of the mower. On two alfalfa plants in the Station greenhouse *Cuscuta epithymum* was permitted to have its own way for over three months. It throve, producing threads three feet in length (see Plate XX, fig. 1), and finally killed the plants, yet it produced no flowers.

When dodder produces seed it seems as if it must be spread by the operations of mowing, tedding and raking; also, in manure made from animals fed on the hay. This would be most likely to happen in the third cutting. Hay from the first cutting is not likely to contain dodder seed because it is made about three weeks before the dodder commences to bloom. Usually, the first flowers of *Cuscuta epithymum* appear about July 15. The second cutting, made about August 1, may contain some dodder seed.

While it seems reasonable to suppose that dodder may be introduced into an established alfalfa field by top dressing it with manure containing dodder seed no instance of the kind has come under our observation. In considering this problem it occurred to the writers that delicate dodder seedlings may find difficulty in establishing themselves upon old alfalfa plants. Hence, the following experiment was made: Early in the spring of 1906 two spots in a two-year old alfalfa field were carefully marked so that they might be readily located at any time. On each spot over an area about two feet in diameter 100 dodder seeds were sown on each of three different occasions: First, on April 18 just as the alfalfa plants were commencing growth; second, on May 5 after a heavy shower; third, on July 9 when the second crop of alfalfa was about a foot high. The seed used in the first sowing was a mixed lot taken from several different samples of alfalfa seed and consisted partly of *C. epithymum* and partly of *C. arvensis* (?); that used in the second sowing was all from one lot of alfalfa seed (different from those previously used) and all *C. epithymum;* while that used in the third sowing was taken from ten different lots of alfalfa seed and contained both *C. epithymum* and *C. arvensis* (?). Throughout the forepart of the season there was an abundance of rain and so far as could be determined there were no unusual conditions

which might interfere with the growth of dodder. Yet no dodder appeared on either of the spots although they were kept under observation for two years. Nothing is known as to the viability of the dodder seed used, but it is scarcely possible that all of the seeds were incapable of germination.

Mr. F. E. Dawley, Fayetteville, N. Y., informs us that in a similar experiment made by him strikingly different results were obtained. Mr. Dawley sowed 27 dodder seeds in an old alfalfa field where there had been no dodder previously and 27 spots of dodder resulted.

It is probable that under favorable conditions dodder may be spread by the mower even when no seeds are formed. Sometimes during a spell of rainy weather the newly-mown hay keeps fresh for several days and the dodder on it not only remains alive but continues its growth and is capable of attaching itself to living alfalfa stems with which it may come in contact. Owing to their tangled condition bunches of dodder-infested hay are often draggeu short distances by the mower. Should it happen that such bunches are dropped upon plants which, in some manner, have been missed by the mower, the dodder finds its opportunity. It is also possible that the dodder may be kept alive until new growth starts. In a wet time alfalfa starts up very quickly after mowing.

That it is possible for dodder-infested hay to bring about infection in the open field is shown by the following experiment: On July 10, 1906, two handfuls of dodder-infested hay each containing about a dozen stalks were placed among alfalfa plants 12 to 14 inches high. The dodder had not commenced to bloom and there were certainly no seeds. The plants and ground were wet at the beginning of the experiment, but subsequent weather conditions were not recorded. The first observations on the experiment were made July 26, three days after the field had been mown. Although the hay had been removed the stubble showed, unmistakably, that infection had occurred in both spots. In one of the spots three plant were so much affected that the dodder was visible at a distance of 20 feet. In the other spot, dodder was firmly established on two plants. Subsequently, two other experiments of this kind were made. In one of these the dodder-infested hay was placed on the bare stubble of a newly-mown field; in the other, among a new growth of alfalfa two to four inches high. The weather being dry the dodder failed to establish itself in both cases.

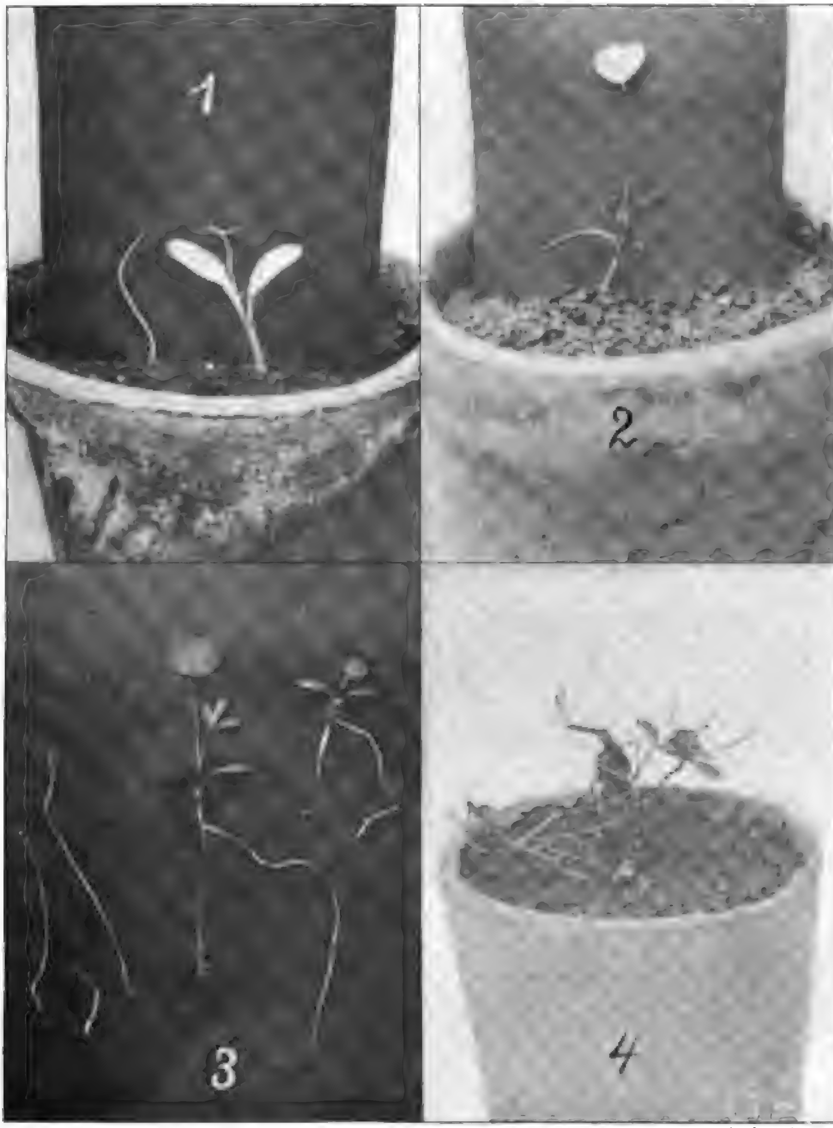

PLATE XVIII.— SEEDLINGS OF DODDER AND ALFALFA.

1, left, dodder seedling; right, alfalfa, seedling; 2, same seedling, three days later; dodder attached to alfalfa, lower portion withering; 3, left, three dodder seedlings; right, dodder seedlings attaching themselves to alfalfa seedlings; 4, dodder attacking alfalfa seedling.

(All natural size.)

PLATE XIX.— UNDER SURFACE OF CROWN OF YELLOW TREFOIL (*Medicago lupulina*) INFESTED WITH DODDER WHICH HAS SURVIVED THE WINTER IN THREAD FORM.

(Cut and photographed Apr. 16, 1906. Natural size.)

The ability of dodder to continue growth as long as the alfalfa remains fresh is easily demonstrated by cutting off infested alfalfa stems and placing them in a moist chamber. In an experiment of this kind made by the writers dodder retained its color and turgidity on cut stems six days during which time the length of the threads increased about one inch. The writers have frequently infected alfalfa plants by placing dodder-infested alfalfa crowns and stems in contact with them in a moist chamber.

Dodder may be propogated also by cuttings; that is, short pieces of the dodder threads placed in contact with alfalfa plants will attach themselves after the manner of seedlings. This was demonstrated in 1880 by Koch[42] and more recently by Pierce[43] and others; also, by the writers who made the following experiment: Five tip-end pieces of dodder threads, four inches in length, were placed among the branches of a ten-inch high alfalfa plant in a moist chamber. In 17 days the plant was thoroughly infested with dodder several threads of which were a foot long.

Although the spread of dodder is not rapid it is by no means confined to the enlargement of the original spots. New spots are formed from time to time. Usually, the new spots appear in the near vicinity of the old ones. In a dodder-infested alfalfa field near Syracuse, examined by the writers in the spring of 1906, some of the large spots were surrounded by smaller ones which were plainly the result of secondary infection. One large spot about 15 feet in diameter was surrounded by 11 small spots two or three feet in diameter. The most distant of these was 20 feet away while four were so near that they almost touched the margin of the parent spot. Whether the small spots originated from seed or from infested hay carried by the mower could not be determined.

The method by which dodder survives the winter is so important a matter that it will be discussed under a separate heading.

PERPETUATION OF DODDER FROM ONE YEAR TO THE NEXT.

In almost all botanical writings the numerous species of Cuscuta are all classed as annuals. It seems to be the prevailing opinion that none of the dodders survive the winter in the thread form and that, in order to perpetuate themselves, they must start anew every year from seeds. Yet, so long ago as 1868, Dr. Julius Kühn[44]

[42] Koch (55).
[43] Peirce (77).
[44] Kühn (57).

made the announcement, based on his own observations, that clover dodder, *Cuscuta trifolii* (=*C. epithymum*) lives over winter on clover and alfalfa plants in Germany. Also, Sorauer,[45] in the second edition of his well-known Handbuch der Pflanzenkrankheiten, published in 1886, states that clover dodder is not annual but perennial and that on perennial plants it perpetuates itself more often by the further growth of the previous year's dodder plants than by the germination of new seeds. On the other hand, Frank[46] ten years later, makes an equally positive statement that the dodders are all annual plants which start anew every year from their seeds. Kerner and Oliver[47] (in 1895) say that the European species of Cuscuta are all annuals, but in the tropics there are perennial species. In 1900 Kühn[48] published another article on dodder in which he characterizes the supposed annual habit of clover dodder as one of those errors which, even in the realm of science, are sometimes held to with remarkable tenacity. After citing his observations made in 1868 he states that he has since confirmed them in various years, even in those having the hardest winters.

With the exception of a note[48a] by the senior author, we know of no published record of any dodder living over winter in the United States. Hillman,[49] in a recent bulletin which may be accepted as presenting the most advanced ideas on dodder in its relation to clover and alfalfa in this country says: "It is an unsettled question whether dodder plants in the field ever live over winter. It appears that very few, if any, survive."

Such being the present status of the knowledge of this subject it is noteworthy that, in New York, *Cuscuta epithymum*, at least, is perennial, regularly living over winter on alfalfa, red clover and certain weeds. This statement is based on observations made in five alfalfa fields as follows:

Field No. 1.—This was a 4-acre field located near Geneva. It was sown in the spring of 1905 and became so badly infested with dodder during the first summer that it was deemed advisable to plow it up. The dodder was not seen to flower, but an examination of some of the left-over alfalfa seed showed the dodder in it

[45] Sorauer (97, 2:48). In a footnote, *Wiener landw. Zeit.* 1880, p. 377, is cited.

[46] Frank (30, 2:523). [47] Kerner and Oliver (53, 1:175).

[48] Kühn (58).

[48a] Rept. Dir. (N. Y.) Farm. Inst. and Norm. Inst. 1906: 69.

[49] Hillman (46, p. 20).

to be *Cuscuta epithymum*. The soil was sandy loam and the field sloped gently toward the east. The first examination was made April 16, 1906. Even at that time the circular bare areas marking the location of the dodder spots of the previous year were easily found. Naturally, attention was first directed to the plants around the margins of the spots.[50] The very first plant dug up showed live dodder! Further search revealed several more specimens of live dodder. In one case, a crown of yellow trefoil (*Medicago lupulina* L.) was covered on the under surface with a dense mat of live dodder threads. (See Plate XIX.) For the most part, the hibernating dodder appeared in the form of turfs of short, stout, yellow threads, one-fourth to one-half inch long, attached to the bases of the branches close down to the ground around the crown of the plant and especially on the undersides of branches lying close to the ground. (See Plate XX, figs. 2 and 3.) Yellow, haustoria-bearing threads tightly coiled around the very lowest parts of the stems were also common, but in no case has the dodder been observed on the root proper.

In a more thorough examination made April 21 live dodder was found to be plentiful in all parts of the field.

Field No. 2.— This field was located near Geneva. The soil was heavy clay. It was sown in the spring of 1904. There being only a few dodder spots the field has been allowed to stand. In the spring of 1906 live dodder was found to occur only sparingly, the dates of observation being April 17 and May 4. It was found on alfalfa, yellow trefoil and red clover. In the spring of 1907 live dodder was more plentiful. An examination made January 4, during a thaw, showed the dodder alive and apparently in good condition. On some of the infested spots it could be plainly seen without stooping down. On March 18, two or three days after the snow had disappeared, live dodder was still abundant; also on March 28. Several other observations (dates unrecorded) were made during April and May of this year and an abundance of live dodder found every time. December 10, 1907, live dodder was found on dandelion leaves. Further observations made during the spring of 1908 showed that dodder had again wintered well. The dates of observa-

[50] In searching for live dodder in early spring it is necessary to cut off the alfalfa plants below the surface of the soil so that the the parts lying next the ground may be examined. To do this with a knife is slow, disagreeable work. The proper tool for the purpose is a short-handled, heavy hoe or light grub-hoe.

tion were February 15, March 25, and April 10. Live dodder was found each time. Some dodder-infested weeds transplanted from the field to the greenhouse on April 10 proved to be daisy fleabane (*Erigeron annuus*). The dodder in this field was *Cuscuta epithymum* as determined from flowering specimens.

Field No. 3.— This field, also near Geneva, was one year old. The soil was sandy loam and the exposure a northerly one. April 20, 1906, live dodder was found here in abundance on alfalfa, yellow trefoil and red clover.

Field No. 4.— This field was located near Syracuse on clay loam with a south exposure. It was two years old and contained numerous large dodder spots. On April 24, 1906, three specimens of live dodder were found. When another examination was made May 7 several additional specimens were found, but it was evident that most of the dodder in this field had winterkilled. Three of the most vigorous dodder specimens found here were on some weed. In order to learn the name of the weed one specimen was transplanted into the Station greenhouse. When it bloomed it was determined as *Erigeron annuus* (daisy fleabane). Subsequently, this determination was verified by Prof. W. W. Rowlee who states that his observations on this species lead him to believe that it is a biennial in this latitude.

Flowering specimens obtained from Field No. 4 showed the dodder to be *Cuscuta epithymum.*

Field No. 5.— This field was located at Bergen. It was sown in the spring of 1904. During 1905 two crops of hay were cut and then cattle were turned on to kill out the dodder, if possible, by close pasturing. Although the field was in an exposed situation and went into the winter close-cropped it was an easy matter to find live dodder in it the following spring (April 30, 1906). Flowering specimens of *Cuscuta epithymum* were taken from this field in August.

While in all of the above observations the appearance of the dodder was such that there seemed no reason to doubt that it was really alive and capable of further growth it was thought best to place the matter beyond all doubt by forcing the hibernating threads into growth. This was accomplished several times by placing the dodder-infested crowns in a moist chamber for a few days. Given warmth and moisture the dodder threads began to lengthen promptly. In six such experiments the dodder-infested crowns were placed in contact with thrifty young alfalfa plants growing in

pots in a moist inoculation chamber in the Station greenhouse. In every case the dodder grew out promptly, established itself on the new plants and there made a profuse growth.

Our observations cover only three springs: viz.: Those of 1906, 1907 and 1908. But Mr. F. E. Dawley of Fayetteville, N. Y., assures us that he observed live dodded early in the spring of 1903, 1904, 1905 and 1906 before there had been time for it to come from seed. For several years Mr. Dawley has been a close observer of alfalfa and dodder and knows whereof he speaks. Even before learning of our observations he expressed the opinion (in conversation) that dodder lives over winter.

Owing to their more spreading habit, the crowns of yellow trefoil and red clover form a better wintering place for dodder than do alfalfa crowns. Daisy fleabane, also, seems to be a favorite winter host for dodder.

Undoubtedly, dodder lives over winter in New York alfalfa fields on alfalfa, yellow trefoil, red clover, dandelion and daisy fleabane. This is not accidental or occasional, but of common occurrence. In the writers' opinion it is the chief method by which dodder is carried over from one year to the next in New York alfalfa fields. It is likely that the seed, also, is an important factor, sometimes, but, as has already been pointed out, dodder usually fails to produce seed in New York.

Although it may be found alive at any time during the spring, dodder does not commence to grow vigorously until the latter part of May. When dodder is in active growth free threads 12 to 16 inches in length may be found running along on the surface of the soil until they come in contact with alfalfa or other stems about which they may twine. *Cuscuta epithymum* grown on potted alfalfa plants in the Station greenhouse has produced threads over three feet in length. (See Plate XX, fig. 1.) The threads are freely branched, clusters of one to four branches (always of unequal length) appearing in the axils of the scales.

METHODS OF ERADICATION.

By giving careful attention to the purity of all alfalfa and clover seed used on the farm, trouble with dodder is avoided, almost entirely; but where such precautions are not taken the pest is liable to be introduced and cause so much damage that something must be done to get rid of it.

Badly infested fields should be plowed up. Oftentimes it is diffi-

cult to determine whether it is best to plow up the field or to kill out the dodder by some other method. In reaching a decision in such cases it should be taken into consideration: That the eradication of dodder is difficult; that the successful reseeding of infested spots is difficult; and that an alfalfa field when once established should last many years. When there are only a few dodder spots scattered through the field they may be given local treatment and the plowing up of the field avoided. A dodder-infested field which has been plowed up may be planted afterward with any of the common farm crops, excepting, perhaps, alfalfa and clover, without any danger of the reappearance of dodder. Dodder is readily subdued by plowing. How much danger there is in reseeding with alfalfa or with clover is uncertain. This subject is discussed more fully on a subsequent page. Much has been written about the eradication of dodder, particularly in Germany, and numerous methods have been recommended:[51] (1) The application of various chemicals, some in the form of spray to kill the dodder without destroying the alfalfa, others to kill both the parasite and its host. In the former method, the substances most frequently used are copper sulphate and iron sulphate; in the latter, sulphuric acid and common salt. (2) Smothering. Some advise covering the infested spots deeply with coarse manure to kill both dodder and alfalfa; others recommend light coverings of manure, finely cut straw, gypsum, etc., which are expected to smother the dodder while the alfalfa breaks through and continues its growth. (3) Close pasturing with sheep or cattle. (4) Close mowing. (5) Digging over the infested spots. (6) Burning over infested spots.

Several of the above methods have been tried in alfalfa fields in this State with varying degrees of success. As yet, New York farmers have had too little experience with dodder to have any established methods of treating it. Our observations and experiments convince us that under New York conditions, the only really practicable methods are those in which both the parasite and its host are killed. Attempts to preserve the life of infested plants invariably result in the escape of some of the dodder which necessitates repeating the treatment again and again. This is the trouble with spraying. It is impossible to reach all of the dodder with the spray. Recommendations for close pasturing and close mowing are based on the false assumption that dodder may be eradicated by preventing

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[51] For the eradication of dodder see Sorauer (97, 2:47); Kühn (58); Kiessling (54); Hillman (46); Dawley (21).

it from seeding. Close pasturing is not only ineffective, but it endangers the life of the alfalfa. The spread of dodder is certainly hindered by frequent mowing, but it can not be eradicated or even kept under control by mowing. Heavy mulching with coarse manure will kill out dodder, but the piles of manure are in the way of the mower and hay rake.

Digging over the infested spots is effective but laborious and, in stony soil, utterly impracticable. Alfalfa plants have large taproots which make them very difficult to dig up with a spade. It is necessary first to cut off the plants below the crown and to dig up the soil afterward. For cutting off the crowns a sharp spade may be used, but a light, broad-bitted grub-hoe is much better. Stones in the soil dull the tool quickly. The dodder-infested crowns must be removed from the field.

Burning over the infested spots is an excellent method if the work is done thoroughly enough to kill every infested plant. This is readily accomplished by using kerosene in combination with dry hay or straw as follows: First, mow the infested spots closely, including a strip of generous width all around the margin. When the hay has become thoroughly dry rake it into a pile in the center of the spot and sprinkle the stubble with kerosene by means of a common garden sprinkler. The application of kerosene should be especially thorough around the margin of the spot — it does not matter so much about the central portion. Next, spread the hay evenly over the whole area. On top of this spread additional dry hay or straw from another source. The quantity of hay and weeds growing on infested spots is rarely sufficient for a thorough job of burning even with the addition of a generous quantity of kerosene. Especially is this true when the work is done during the first week in May which is the proper time for it. When the hay is in position it should be fired simultaneously at three or four different points on the windward side. If possible, the burning should be done when there is little wind in order to insure more complete combustion and to avoid severe scorching of the surrounding alfalfa. The burning may be done with hay alone, but it is necessary to use a large quantity in order to insure thorough work. The kerosene draws the fire down to the ground close around the crowns of the plants where it is most needed.

Whichever method is employed (burning or digging) the best time to do the work for the first time is during the first week in May. The dodder spots are then more easily located and their

boundaries more sharply defined than at any other time. The alfalfa will then stand four to eight inches high while the weeds on the interior of the spot have scarcely started. Moreover, at this time, the live dodder is closely confined to a few plants and there are no long threads so that the danger of leaving some of the dodder undestroyed is not as great as it is later in the season. Of course some unnecessary work may be done on spots already extinct since it is difficult to distinguish active from extinct spots so early in the season; but this is probably offset by the increased size of the spots later in the season. Dodder spots escaping the first treatment should be destroyed whenever discovered. At each mowing a careful lookout should be kept for new spots. If any are discovered they should be marked so that they may be found again and destroyed after the hay is removed. To the inexperienced it may appear that the ideal time to treat dodder in just after haying. However, such is not the case. The infested spots are then very difficult to locate.

Both in burning out and in digging out dodder it is necessary to sacrifice a strip of alfalfa two to three feet wide all around the margin of the spot in order to make sure that none of the dodder escapes. If the spot is sharply outlined a strip two feet wide is likely to be sufficient; but where the margin of the spot is indefinite it is advisable to include a wider strip.

If it is desired to reseed the infested spots the digging out method is preferable to any other, provided the soil is not stony, since the spots must be dug up anyway before they can be reseeded. However, we doubt the advisability of reseeding. In experiments made by the writers the reseeding of infested spots has been only partially successful. The principal difficulty is with weeds. The soil of infested spots is sure to be full of weed seeds, particularly those of green and yellow fox-tail grasses. Besides, if the dodder ripened seed there is danger that the alfalfa seedlings may become affected and thus foil the attempt at eradication.

RESEEDING INFESTED FIELDS.

When it becomes necessary to plow up dodder-infested alfalfa fields there frequently arises the question as to how soon the field may be safely reseeded with alfalfa. Before this question can be answered satisfactorily it must be known whether the dodder produced seed. If the dodder ripened seeds there may be danger of the appearance of dodder in the new seeding. Exactly how long

dodder seeds may retain their viability when buried in the soil is not known, but it is believed to be several years. Hence, if the dodder is known to have produced seed the land should be planted with other crops for one or two years, at least, before it is reseeded with alfalfa. On the other hand, if the dodder did not seed it is entirely safe to reseed with alfalfa at once. As a rule, dodder does not seed in New York so that the risk in reseeding infested fields is probably not great.

The writers have tested this in five different fields of one-fourth acre each. One of these fields, located at Fayetteville, was two years old when plowed up because of dodder. It was then planted with tomatoes for two seasons. In the spring of 1906 it was reseeded with alfalfa seed known to be free from dodder. No trace of dodder was found in the new seeding which was kept under observation for two years. Another field, near Geneva, ruined by dodder in 1905 during the first season after sowing, was plowed up in the spring of 1906 and reseeded in May with dodder-free seed. No dodder appeared up to the close of 1908. A one-year old dodder-infested field at Oakfield was plowed up in the spring of 1906 and at once reseeded. No dodder appeared during the time the field was under observation, viz., one year. A fourth field, located near Canandaigua, was ruined by dodder during the first season. In the spring of 1907 it was plowed up and reseeded and has remained free from dodder up to date (October, 1908). The fifth field was located at Caywood. It was first seeded in the spring of 1905. Dodder became very abundant the same season, but the field was allowed to stand until about June 20, 1906, when it was plowed up and planted to beans. The following spring it was reseeded with alfalfa. The writers did not see this field during the autumn of 1907, but the owner informs us that no dodder appeared in it. An interesting feature of this field is the appearance of one colony of dodder among the beans. Perhaps this came from seed, but there is another way in which it may have originated. Many alfalfa plants survived the plowing in 1906. They came up thickly among the beans. It is quite possible that some of these plants harbored the dodder until after the beans were large enough to receive it.

YELLOW TREFOIL.

Owing to the occasional adulteration of alfalfa seed with the seed of yellow trefoil (see page 188) this plant has recently come into considerable prominence in New York. The name yellow trefoil

properly belongs to the plant known to botanists as *Medicago lupulina* L., but sometimes it has been applied to other plants.[52] Yellow trefoil so closely resembles alfalfa as to be easily mistaken for it. The most striking difference is in the color of the blossoms, yellow trefoil having yellow blossoms while those of alfalfa are bluish or purple. When adulterated seed has been used the fraud is not detected, usually, until the plants bloom, which is in June of the second season after sowing. Yellow trefoil blooms from a week to ten days earlier than alfalfa.

In botanical works *Medicago lupulina* is sometimes described as annual and sometimes as "annual or biennial." Our observations convince us that in New York alfalfa fields it is regularly a biennial as announced elsewhere by one of the writers.[53] June 4, 1906, the writers sowed a tenth-acre plat with alfalfa seed which was heavily adulterated with yellow trefoil and two kinds of bur clover (*Medicago hispida* and *M. arabica*). During September of the same year some of the trefoil plants blossomed and produced seed, but the great majority first began to bloom in the spring of 1907. Some blossoms appeared the last week in May and from June 1 on to the time of making the first cutting (June 28), the field was yellow with bloom. No trefoil appeared in the second or third cutting. Many farmers have had similar experience — the trefoil becomes conspicuous during the forepart of June in the second season after sowing and after the first cutting disappears from the field almost completely. Even when infested fields are plowed up and reseeded the yellow trefoil does not reappear to any great extent. In the experiment described above the plants of *Medicago hispida* flowered and produced seed-pods in abundance during the autumn of 1906, but *Medicago arabica* did not bloom and both species were completely killed by the winter.

That plants of yellow trefoil live over winter in alfalfa fields, and also in lawns, is further proven by the following experiment: On March 29, 1907, nine plants suspected of being *Medicago lupulina* were transplanted into the Station greenhouse. Six of the plants were taken from a one-year-old alfalfa field and the other three from a well-kept lawn of several years standing. In due course of time all nine plants bloomed showing themselves to be yellow trefoil as suspected.

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[52] U. S. Dept. Agr. Farmers' Bul. 102:33; La. Sta. Bul. 53:40; Mass. Sta. Rpt. 10 (1892): 190.

[53] French (33).

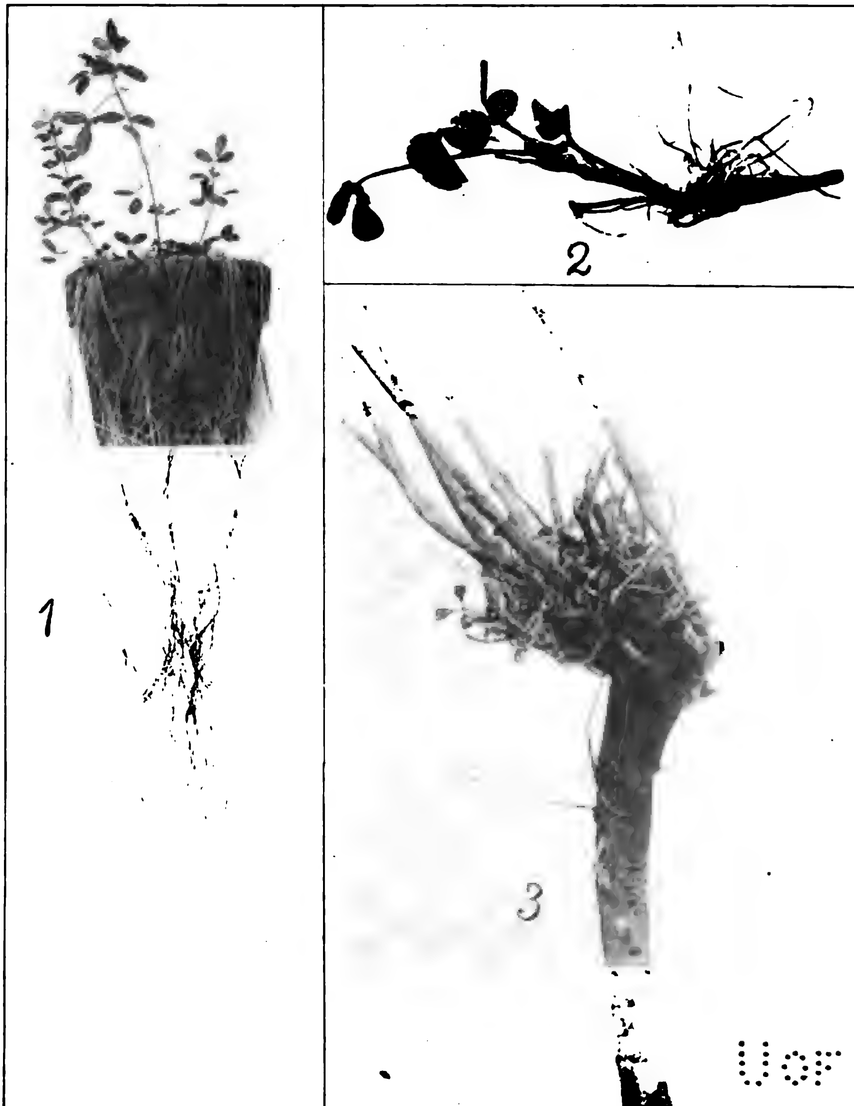

PLATE XX.— DODDER ON ALFALFA.

1, Dodder growing on potted alfalfa plant in greenhouse; some threads over three feet long. 2, Alfalfa branch bearing dodder threads which have survived the winter; cut April 21, 1906. 3, Dodder wintering on alfalfa crown; dug in March, 1908.

(I, One-sixth naturalsize; others natural size.)

PLATE XXI.— ALFALFA SEEDLINGS IN VARIOUS STAGES OF GROWTH.

Age from time seed was sown: 1, 9 days; 2, 16 days; 3, 23 days; 4, 31 days; 5, 42 days; 6, 72 days.

(All natural size.)

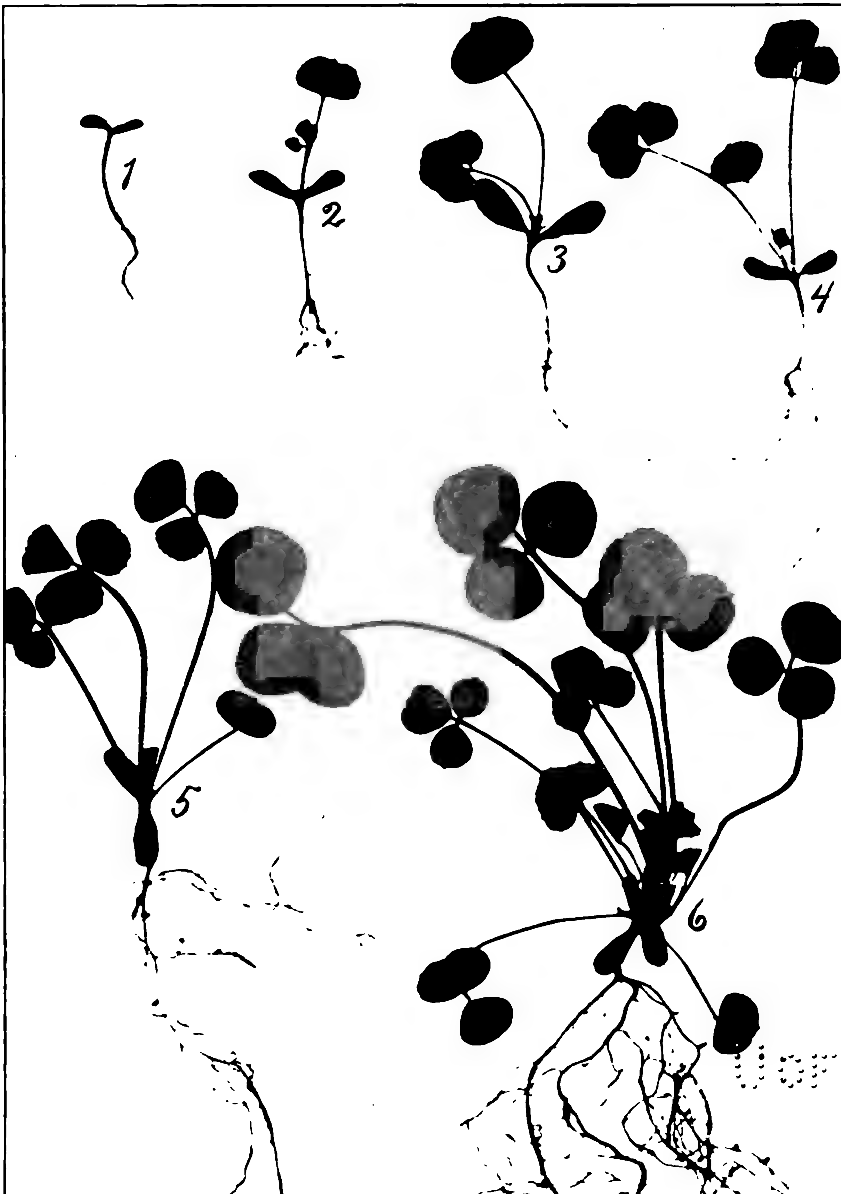

Plate XXII.— Seedlings of Yellow Trefoil in Various Stages of Growth.

Age from time seed was sown: 1, 16 days; 2, 28 days; 3, 31 days; 4, 42 days; 5, 53 days; 6, 72 Days.

(All natural size.)

PLATE XXIII.— ROOT SYSTEMS OF ALFALFA AND YELLOW TREFOIL COMPARED.

1, Yellow trefoil root; 2, alfalfa root. Plants of same age — ten months.

(Dug and photographed March 29, 1907. Natural size.)

Up to the time of blooming, yellow trefoil and alfalfa are so much alike in appearance that they are separated with difficulty except by one who is well acquainted with them. This is especially true in the earlier stages of growth. The seedlings of the two species are strikingly alike. (Compare Plates XXI and XXII.) The writers have sought in vain for morphological or anatomical differences by means of which one unfamiliar with the plants might distinguish one from the other with certainty. Yellow trefoil plants vary greatly in habit according to their environment. In lawns they spread their branches close to the ground, and blossom and seed in spite of frequent close mowing. Among clover and alfalfa they grow more upright and may attain a height of over two feet. But, in general, yellow trefoil is smaller than alfalfa, more spreading in habit and the leaflets are broader in proportion to their length. The most reliable characters by which the two species may be separated in early spring are (1) The habit of growth of the crown; and (2) the character of the root system. The stems of yellow trefoil being procumbent, the crown has a spreading habit and lies close to the ground; while the crown of alfalfa is upright in habit. The root systems offer a more striking contrast. Alfalfa has a large tap-root with very few side roots; while yellow trefoil has a small tap-root which is nearly concealed in a mass of fibrous side roots. (See Plate XXIII.)

Yellow trefoil is not a troublesome weed. No special methods are required for its eradication. It readily succumbs to tillage. Nevertheless, its substitution for alfalfa is objectionable because, as a fodder plant, it is greatly inferior to alfalfa. It makes but a small amount of hay and dies after the first cutting of the second season, whereas alfalfa is perennial.

In parts of Europe yellow trefoil is sometimes sown for sheep pasture, but in America it is not considered worthy of cultivation. Although it grows spontaneously in meadows, pastures and lawns and along roadsides throughout the greater part of New York it is rarely found in quantity except where adulterated alfalfa or clover seed has been used. The yellow trefoil seed imported into the United States from Europe is practically all used for the adulteration of alfalfa and clover seed.[54]

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[54] Brown (9).

WEEDS.

All writers on alfalfa culture agree that weeds are one of the chief hindrances in starting alfalfa. This applies in New York quite as much as it does elsewhere. Many of the failures with alfalfa in this State are due to sowing on foul land. Practically all of the trouble with weeds comes during the first season. Alfalfa seedlings can not successfully compete with weeds; but after the first year the alfalfa plants are able to hold their own against even the most aggressive weeds. In established fields weeds are rarely troublesome. In New York, it is doubtful if weeds ever run out alfalfa after the first season. When old alfalfa fields become overrun with weeds and grass it is likely that the stand of alfalfa has been thinned by heaving and other forms of winter injury, not by the competition of the weeds.

The weeds which are most likely to cause trouble in newly-seeded alfalfa fields in New York are crab grass (*Digitaria sanguinalis*), green foxtail (*Setaria viridis*), yellow foxtail (*Setaria glauca*), lamb's quarters (*Chenopodium album*), pigweed (*Amaranthus retroflexus*), ragweed (*Ambrosia artemisiifolia*), and barnyard grass (*Echinochloa crusgalli*). Charlock (*Brassica arvensis*) and quack grass (*Agropyron repens*), also, are troublesome, but occur less frequently. It is folly to sow alfalfa on land badly infested with quack grass.

In established fields, narrow-leaved plantain and dandelion are very abundant and persist indefinitely. Many alfalfa fields, even thickly seeded ones, are yellow with dandelion blossoms about May 15 and a few days later white with the seed-heads which stand above the alfalfa. Wild carrot and ox-eye daisy, so abundant and conspicuous in New York meadows, do not thrive in alfalfa fields except on bare spots, *e. g.*, those caused by dodder. Such spots may be conspicuously white with ox-eye daisy blossoms at the time of the first cutting. Sweet clover maintains itself but two years. During the latter part of May and forepart of June, in the second season after sowing, sweet clover plants growing among alfalfa may be readily distinguished by their taller and coarser growth. At the time of the June cutting the sweet clover plants stand 12 to 18 inches above the alfalfa. Being a biennial and unable to ripen seed, owing to the frequent mowing of the alfalfa, the sweet clover disappears entirely after the second season. Sweet clover hay is not relished by cattle. On rich soil, chickweed (*Stellaria media*) persists in al-

PLATE XXIV.—ALFALFA FIELD ON STATION FARM.

Left, badly infested with curled dock introduced with manure at time of seeding in spring of 1901; right, free from dock. After the first cutting the dock disappeared.

(Photographed June 12, 1902.)

falfa fields. It begins to grow as soon as the snow goes off in spring and becomes conspicuous during April as a green carpet covering the ground between the alfalfa crowns. It may make sufficient growth to add materially to the bulk of hay in the first cutting.

Curled dock (*Rumex crispus* L.) is not troublesome in alfalfa fields. The following account of an experience with dock at the Station brings out prominently two important points in regard to this weed: (1) The danger of spreading it in manure; and (2) its inability to endure in an alfalfa field. In the autumn of 1900 a strip of corn stubble on the Station farm was spread with manure made from hay purchased of a neighboring farmer. The following spring the manure was plowed under and the land seeded with alfalfa. In June, 1902, curled dock came up thickly among the alfalfa. A count made in an average part of the field showed 209 dock plants per square rod. By June 11 the dock had thrown up its flower stalks which towered above the alfalfa causing the infested strip to stand out prominently in contrast with the adjacent non-infested fields of alfalfa on either side (See Plate XXIV). The first cutting was made June 12 before the dock had ripened any seeds. This was the end of the dock. At the time of the second cutting, made about August 1, not a single dock plant was to be seen. Neither did any appear the following season. The history of the land and the character of the seed being fully known there can be no doubt that the dock came from seeds in the manure.

The best method of dealing with the weed problem is to free the land of weeds as thoroughly as possible before sowing alfalfa. This is accomplished in various ways. The crop preceding the alfalfa should be one which permits of thorough cultivation as, for example, corn or cabbage, and no weeds should be allowed to ripen seed. If stable manure is used it should be well rotted and plowed under. The use of manure as a top-dressing just before sowing alfalfa is usually objectionable because of the weeds which are introduced with it. The land should be plowed in early spring and thoroughly fitted. It should then be harrowed at frequent intervals until seeding time to induce the germination of weed seeds in the surface layer of the soil. The time of seeding should be governed somewhat by the weediness of the land. If the land is reasonably clean, June 1 is a suitable time for seeding; while on weedy land, later seeding (about August 1) gives better results.

When proper cleaning of the land has been neglected so that weeds come up thickly and threaten to smother the young alfalfa

it should be promptly clipped, but not mown closely. Close mowing may ruin young alfalfa. The mower cutting bar should be run at least four inches above the ground. This is the treatment usually recommended for weeds. It is widely practiced in New York. The treatment of charlock by spraying with a solution of copper sulphate, so successfully used in oat fields, can not be used in alfalfa fields. Alfalfa is injured by the spray.

FUNGUS DISEASES.

LEAF SPOT.[55]

(*Pseudopeziza medicaginis* (Lib.) Sacc.)

Leaf spot, also known as rust and blight, is by far the most important fungus disease affecting alfalfa in New York. In fact, it is the *only* really important fungus disease. It appears in all parts of the State where alfalfa is grown, on all kinds of soil, in all situations and under almost all conditions. Probably, more or less of it may be found in almost any alfalfa field in any season, in dry weather as well as in wet. Some severe cases have been observed in the midst of an August drought. It may make its appearance at any time after about June 1. The lower leaves are the first to be attacked. They show numerous small brown spots, turn yellow and fall. (See Plate XXV.) In severe attacks so many of the leaves fall that the value of the hay is much impaired.

Fields of all ages and in almost any stage of growth may be attacked. Newly-seeded fields are sometimes ruined by leaf spot. Older fields may suffer very severely from it but are rarely, perhaps never, killed outright. While it may seriously affect the first cutting in June, the second and third cuttings are the ones most likely to be injured. Overripe plants are especially liable to attack. Through extensive dropping of the lower leaves, affected plants present a trimmed-up appearance. The disease may also appear on the stems in the form of elliptical black spots 1 to 3 millimeters in length. Usually, but not invariably, leaf spot causes the leaves to

[55] Although there are at least three other leaf spot diseases of alfalfa in New York it seems best to reserve this name for the common and well-known disease caused by *Pseudopeziza medicaginis*. If it becomes necessary to use common names for the unusual diseases caused by Ascochyta, Stagonospora and Cercospora they may be designated as Ascochyta leaf spot, Stagonospora leaf spot and Cercospora leaf spot respectively.

PLATE XXV.— ALFALFA AFFECTED WITH LEAF SPOT (*Pseudopeziza medicaginis*).
Affected leaves fall prematurely leaving the stems bare.
(Natural size.)

turn yellow. Sometimes, even in severe attacks, the leaves show scarcely any tendency to become yellow.

The diseased spots are plainly visible on both sides of the leaf, but most conspicuous from the upper surface. In color, they are brown or black. Their general shape is circular with the boundary irregular and not sharply defined. The size of the spots varies from a mere speck to 1.5 or 2 mm. in diameter. They are irregularly distributed over the leaf. Many of the spots, even on leaves which have lain on the ground several days, show no signs of Pseudopeziza apothecia. The fungus is somewhat slow in fruiting. Under a hand lens the apothecia first appear as small shiny elevations, amber colored or nearly black. In this condition they contain asci and paraphyses, but no ascospores. Soon the shiny elevations crack at the summit, the crack gradually widening until the apothecium becomes cup-shaped, flat or even elevated at the center, while the edges of the ruptured epidermis stand up all around the margin. Ascospores may be found at any time after the rupturing of the epidermis, but usually not before. They are hyaline, non-septate, elliptical, 8–11 x 4-6 and there are eight in each ascus arranged in sub-biseriate fashion.[56] In 1907, mature ascospores were found at Geneva on June 7, but they were not yet plentiful. However, the spring of 1907 was a backward one — about ten days later than usual. It seems probable that, at Geneva, the first ascospores mature about June 1. After this date they may be found at any time until frost.

Leaf spot often appears in alfalfa fields on soil which has not previously grown alfalfa. When this happens in fields which have been strewn with soil from another alfalfa field for the purpose of securing inoculation with nodule bacteria the leaf spot infection is satisfactorily accounted for, since without doubt spores of the leaf fungus may be disseminated with soil. But it is noteworthy that the writers have observed severe attacks of leaf spot in fields on which no alfalfa soil had been used and where there were no other alfalfa fields in the vicinity. In such cases, the infection must come either from spores sown with the seed or from host plants of other species. Both methods are possible. It is highly probable that the disease may be transmitted with the seed. Red clover is attacked by *Pseudopeziza trifolii* (Bernh.) Fckl. which is considered by some botanists to be identical with *P. medicaginis* while others regard it

[56] Illustrations of *Pseudopeziza medicaginis* on alfalfa are given by Chester (14, p. 82); Combs (17); Briosi and Cavara (8, No. 262); and Saccardo (Fungi Italici, No. 1390).

as a distinct species. Yellow trefoil (*Medicago lupulina*) is known to serve as a host for *P. medicaginis* although, according to our observations, it is a much less congenial host than alfalfa. The writers have observed repeatedly that in fields containing both yellow trefoil and alfalfa the trefoil plants are but slightly affected with leaf spot even when the alfalfa plants mingled with them are badly diseased.

Notwithstanding the probability that the seed used may be a source of infection it is unlikely that leaf spot can be avoided by any method of seed disinfection. Neither is the liability of disseminating leaf spot a serious objection to the use of alfalfa soil for inoculation. Chester's experiments,[57] and also those made by Combs,[58] indicate that infection through the air is common. Apparently, alfalfa leaf spot is one of those widespread, easily disseminated diseases which it is useless to try to prevent completely. The only practicable method of control known is the widely-recommended one of mowing the plants whenever they turn yellow and become so badly diseased that their growth is stopped or severely checked. Mowing causes the plants to throw up new shoots which may outgrow the disease. Newly-seeded fields should not be mown closely — only the tops of the plants clipped off as in the control of weeds. Close mowing, if followed by a period of dry weather, may kill the alfalfa. When the disease makes its appearance shortly before the hay crop is ready to harvest and begins to trim up the plants it is advisable to mow the field a few days early in order to avoid the loss of leaves which may be considerable if cutting is delayed. Once well started, the disease progresses very rapidly after the alfalfa begins to bloom.

WILT.

(*Sclerotinia libertiana* Fckl.)

June 12, 1899, it was observed that in an alfalfa field on the Station farm some of the stalks were wilted and others quite dead and dry. The affected stalks were scattered here and there through the field. It was plain that death had come to them rather suddenly when they were nearly ready to bloom. Upon tracing the wilted shoots back to the root (the plants were large and badly lodged) there was invariably found somewhere on the stem a dead, brown section 3 or 4 inches long which was plainly the seat of the trouble.

[57] Chester (14, p. 83).
[58] Combs (17).

Here, the stem was infested by a fungus having whitish mycelium and compact, black sclerotia. (See Plate XXVI, fig. 5.) In one portion of the field, lower and wetter than the rest, there were small areas on which nearly all of the plants were diseased. On some of the stems the white mycelium was abundant. No spores of any kind were found, but sclerotia were plentiful. The sclerotia were but loosely attached to the stems so that in extricating the diseased stalks many of the sclerotia would be knocked off. Usually, the diseased section of the stem was a foot or more from the root and not in contact with the ground.

The fungus causing the disease was supposed to be the *Sclerotinia trifoliorum* Eriks. given in all the text books on plant diseases as the cause of a stem rot of clover[59] and which is said to attack also alfalfa.[60] However, Prof. R. E. Smith, to whom specimens of the fungus were sent for identification, reported that the sclerotia are entirely similar to those of *Sclerotinia libertiana* and that they produce a Peziza form which leaves no doubt that the fungus really is *S. libertiana*.[61]

In 1902 further observations were made on the alfalfa wilt disease in the same field. On June 9 of that year only an occasional affected stalk could be found; but by June 18, just before the first cutting, there were large areas on which over 50 per ct. of the stalks were killed by the disease. Where the plants were lodged the stems were mostly brown and many of them were brittle. The lower leaves were all dead, being frequently fastened together and to the diseased stems by the Sclerotinia hyphæ. Often the hollow stems were filled with mycelium and sometimes they contained also sclerotia about the size and shape of a wheat kernel. (See Plate XXVI, fig. 5.) At the time of the second cutting (August 1) the field was entirely free from disease. The alfalfa was of the Turkestan variety. This field was completely killed out by the hard winter of 1903–4, but it was immediately reseeded. No diseased stalks were found in 1905 and only a few in 1906 and 1907.

Another small field on the Station farm seeded in the spring of 1906 showed traces of the wilt disease in 1907. Six stalks badly

[59] The occurrence of such a disease of crimson clover in America has been recorded by Chester (14, p. 84) and Halsted (N. J. Sta. Rpt. for the year 1897:314). The writers observed a Sclerotinia crown-rot of red clover at Phelps, N. Y., in 1901.

[60] Prillieux (80, 2:419).

[61] Smith (96, p. 404).

wilted but not quite dead were found on June 6 when the alfalfa was 10 to 12 inches high. Upon seeking the cause, it was found that the wilted shoots were attacked near the surface of the soil by a fungus producing a luxuriant cottony white mycelium. Underneath the cottony growth of fungus the bark was soft rotten, but the interior of the stem was not yet discolored. Probably this was an early stage of the disease observed in 1899 and 1902. The only important difference is in the point of attack being near the root. The greater luxuriance of the mycelium and the absence of black sclerotia are to be accounted for by the wet weather and the immature condition of the fungus. The hyphæ resembled those of Sclerotinia, and there were a few light-colored immature sclerotia. On June 18, four other stalks similarly affected were found in this field and one of them showed a typical black sclerotium.

At Hicksville, Long Island, June 11, 1907, there were observed two dead alfalfa stalks apparently killed by some fungus which had attacked the stems just above the surface of the soil, but the only fungus in evidence was a species of Botrytis which was fruiting profusely. This is the only instance in which we have observed Botrytis in association with a wilt disease of alfalfa.

During 1907 occasional specimens of the wilt disease were observed in several alfalfa fields in different parts of the State.

Although apparently capable of causing considerable damage when the conditions are favorable, it is unlikely that this disease will become a troublesome one.

ANTHRACNOSE.

(*Colletotrichum trifolii* Bain.)

Colletotrichum trifolii is a recently-described fungus which, according to Bain and Essary, is one of the chief causes of failure with clover in Tennessee. All at present known of its relation to alfalfa is contained in the writings of the above-mentioned investigators who state that it occurred rather abundantly on alfalfa in Tennessee in 1906 and that J. M. Westgate has observed it doing considerable damage to alfalfa in Virginia.[62]

We have found this fungus in several alfalfa fields in New York, but our study of it has been confined to a four-year-old alfalfa field on the Station farm where it first came to our attention August 22, 1907. The alfalfa was then 8 to 10 inches high after the sec-

[62] Bain and Essary (3), (4).

ond cutting. Owing to dry weather it had been making a very slow growth. Here and there through the field occasional stalks were dead or wilting. Sometimes, whole plants were dead. In other cases living and dead stalks were found in the same stool.

In seeking the cause of the trouble our attention was first attracted by elliptical, sunken spots appearing on some, but not all, of the dead stems. In two instances, the top of the stalk was killed by a single large spot about two inches below the tip. While some of the dead stalks bore several spots there were usually only one to three on each stalk and they appeared too small to be responsible for the death of the stalks. Besides, similar spots were sometimes found in healthy stalks. It was plain that, in the majority of cases, the death of the stalks was due to something else than the spots.

The spots were elliptical, sunken, five to six millimeters long, with sharply-defined outline; their color was usually gray sprinkled with specks of darker color. Under the microscope the dark-colored specks proved to be the acervuli of some Melanconiaceous fungus, apparently a species of Glœosporium. The spores were hyaline, non-septate, about 12 x 4.5 μ, rounded at both ends and frequently somewhat narrowed at the middle. However, it was found that on the older spots some of the acervuli were supplied with setæ, also that dead stubs in the crowns of affected plants were thickly covered with a dark-colored fungus having similar spores and setæ. Specimens of the fungus were sent to Prof. Bain who identified it as his *Colletotrichum trifolii.*

Further study of the affected plants revealed the fact that the death of the stalks was usually due to a diseased condition of the crown which might be very properly designated black crown. Upon peeling the bark from the large branches of the crown the woody part was found conspicuously blackened below the point of attachment of the dead stalks. When there were living and dead stalks springing from the same crown the wood blackening occurred only in the portion bearing the diseased stalks. When all the stalks were dead the blackening extended all through the crown and even into the upper portion of the tap-root. Microscopic examination showed the blackening to be due to the presence of a compact black fungus mycelium closely interwoven with the wood fibers.

Besides *Colletotrichum trifolii,* the diseased crowns commonly bore two other species of fungi; viz., a Dendrodochium producing multitudes of hyaline, non-septate, elliptical, straight or slightly

curved spores measuring 5–7 x 3.5–4 μ; and a Fusarium with hyaline, curved spores usually 3-septate and measuring 35–53 x 5–7 μ Both species were whitish, but the Dendrodochium was in little heaps which often showed a tinge of pink, whereas the Fusarium was more diffuse in habit and with a tendency to become bluish green.[63] Although no inoculation experiments have been made we are of the opinion that the Dendrodochium and Fusarium are only saprophytes and that *Colletotrichum trifolii* is the cause of black crown. One reason for this opinion is the following observation: On September 26, 1907, 14 pieces of blackened woody tissue from as many different alfalfa crowns were placed in a moist chamber. From each piece the bark had been completely removed exposing a clean, smooth surface of blackened wood. At the end of 48 hours a microscopic examination was made. Twelve of the pieces were thickly covered with acervuli of *Colletotrichum trifolii.* Both spores and setæ were produced in abundance. There was little or no superficial mycelium — the Colletotrichum acervuli were seated directly on the cut surface of blackened wood covering it almost completely. On some of the pieces Dendrodochium and Fusarium also developed.

From our limited observations on this Colletotrichum we should say that the greater part of the damage done to alfalfa results from its attack on the crown of the plant and that the stem spots are relatively unimportant. We have never seen the leaves affected. The bad reputation of this fungus in Tennessee makes it of considerable interest to New York farmers. To what extent it occurs in New York clover fields we are unable to say, no investigation of clover fields having been made.

ROOT-ROT AND DAMPING OFF.

(*Rhizoctonia* sp. and *Pythium de baryanum* Hesse.)

In various parts of Europe there is a destructive root-rot of alfalfa caused by *Rhizoctonia medicaginis* DC. The disease manifests itself in the form of circular dead spots in the field. The roots of affected plants are thickly covered with a violet-colored mycelium. Fortunately, this fungus is rare in America. No record of its occurrence in New York is known to us and we have never seen

[63] Grown in pure culture on plugs of sugar beet this Fusarium is bluish green very much like *Penicillium glaucum.* On unneutralized alfalfa agar it is cream colored.

it here although we have been on the lookout for it since 1900. There have come to our attention a few cases of mysterious dying of alfalfa in circular spots, but we have been unable to definitely connect any Rhizoctonia with such trouble. Yet there are indications that Rhizoctonia may sometimes be harmful to alfalfa.[64]

In the spring of 1907 Mr. C. H. Kingsbury, Barnard, N. Y., sent to the Station 25 alfalfa crowns taken from a dead spot in his alfalfa field. One of these crowns bore several typical Rhizoctonia sclerotia, but the other 24 showed no sign of Rhizoctonia. Pure cultures of the Rhizoctonia were obtained and some inoculation experiments made on alfalfa seedlings, also on five-months-old alfalfa plants in pots. There were no indications that either the seedlings or the older plants were in any way injured although the conditions must have been favorable to the growth of the Rhizoctonia. One of the writers made an examination of the Kingsbury field, but the cause of the trouble could not be determined.

In April, 1907, a box of alfalfa seedlings in the Station greenhouse "damped off" quite badly. Microscopic examination of the affected seedlings showed them to be infested with Rhizoctonia to so great an extent and in such manner as to leave little doubt that this fungus was responsible for their death. Later it was proven by inoculation experiments with pure cultures that the Rhizoctonia actually is capable of causing damping off of alfalfa seedlings provided there is present an abundance of moisture. Older plants, also, were killed by artificial inoculation, but only when their crowns were kept constantly moist by placing wet moss around them. We have never seen alfalfa seedlings in the field damped off by Rhizoctonia, but our observations have been too few to warrant the conclusion that it does not occur. In a newly-seeded alfalfa field at Halcottville, N. Y., the seedling plants over large areas were destroyed by something not visible to the unaided eye. Unfortunately, there

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[64] It would be strange indeed if alfalfa is not sometimes attacked by Rhizoctonia which is more or less parasitic on a great variety of plants and is very common in New York soils. (See N. Y. Sta. Bul. 186.) In 1900, some five-months-old alfalfa plants growing in the greenhouse were inoculated with three kind of Rhizoctonia,— from phlox, cabbage and carnation. Although the conditions were made highly favorable for the growth and attack of the Rhizoctonia no injury resulted to the plants treated with phlox Rhizoctonia and cabbage Rhizoctonia, but on one of the three plants treated with carnation Rhizoctonia four shoots died within a month after inoculation. Three of the dead shoots appeared to have been killed by the Rhizoctonia while the fourth probably died from another cause.

was not an opportunity to make a thorough investigation into the cause of the trouble. A few of the dead seedlings which were examined microscopically showed traces of Rhizoctonia.

In a field at Ensenore, N. Y., some alfalfa plants nine inches high wilted and died after the manner of plants attacked by *Sclerotinia libertiana* or *Colletotrichum trifolii* although neither of these fungi was in evidence. There is reason to believe that they were killed by Rhizoctonia, with which the roots were thoroughly infested.

To what species the above-mentioned Rhizoctoniæ belong is not known. It can only be stated that the one causing damping off of seedlings in the Station greenhouse is different from the one found in the Kingsbury field. When grown on potato agar (slightly acid, neutral or slightly alkaline) the former produces a conspicuous dark-brown discoloration of the medium, whereas the latter discolors it only slightly. This character may be useful in the identification of the damping-off Rhizoctonia. Such discoloration of the medium is not common among the species of Rhizoctonia.

In one instance a box of alfalfa seedlings in the Station greenhouse developed a bad case of damping off due to *Pythium de baryanum* Hesse.

DOWNY MILDEW.

(*Peronospora trifoliorum* De By.)

A few specimens of this fungus were collected on the Station farm October 3, 1907. In the forepart of June, 1908, it again occurred sparingly in two of the Station alfalfa fields; also, in fields at Canandaigua, Potsdam, Earlville and Fayetteville. In Europe, *Peronospora trifoliorum* is a well-known parasite on various species of Trifolium, Medicago, Melilotus and some other Papilionaceæ. In America, it appears to be uncommon on alfalfa although specimens on this host, collected in Colorado, have been distributed in Fungi Columbiani, No. 2246, and quite recently it has been reported from Kansas.[65] No previous record of its occurrence on alfalfa in New York is known to us. It is unlikely to become of economic importance.

The fungus appeared on leaves situated in the upper part of the plant, particularly on young leaves at the tips of shoots. Some of the leaflets were affected only at the tip, some only on the proximal portion and others all over, the affected portion being yellowish,

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[65] **Freeman (32).**

gray or, occasionally, purple. Frequently, the margins of affected leaflets were curled downward. The dichotomously branched condiophores occurred on both surfaces of the leaflet, but most abundantly on the lower surface. Violet, elliptical or ovate conidia were abundant. Round, brown oöspores, formed within the tissues of the affected leaves, were common in specimens collected in October and some, also, were found in specimens collected June 5 to 10. The dimensions of the conidia and oöspores, as determined by the writers, are somewhat greater than are usually given for this species. The most common size of the conidia was 21 x 28 μ and of the oöspores 35 μ in diameter.

On some of the leaves collected in October, there was associated with the Peronospora a Hyphomycetous fungus which may have been the *Ovularia medicaginis* described and illustrated by Briosi and Cavara in their Funghi Parassiti, No. 303.

ASCOCHYTA LEAF SPOT.

(*Ascochyta* sp.)

This is an undescribed disease discovered in alfalfa fields in the vicinity of Geneva. It attacks the lower leaves almost exclusively. While it may occur on normal green leaves it is most common on those which have begun to turn yellow and are about ready to fall. In the great majority of cases it appears in the form of V-shaped, dead, brown areas, 5 to 12 mm. long, at the tips of the leaflets. Frequently, the spots are on the margin and semi-circular in shape, while in some cases circular, dead, brown spots occur on the interior of the leaflet entirely surrounded by healthy tissue. The boundaries of the spots are rather indefinite. (See Plate XXVI.)

Between May 28 and June 12, the period during which most of the observations were made, pycnidia well filled with spores were to be found on nearly all of the spots. The pycnidia, as seen under a hand lens, are light brown, depressed and visible on both surfaces of the leaf. They are delicate in structure, 100–150 μ in diameter, and ostiolate with a ring of darker brown surrounding the ostiolum. When the pycnidia are placed in water the spores escape in gelatinous rope-like or wedge-shaped masses. The spores are hyaline, mostly non-septate, 2.5–3.5 x 6–12 μ, straight or slightly curved and rounded at the ends. Mingled with the non-septate spores, particularly in the more mature pycnidia, are one-septate spores which are often narrowed at the middle or slightly constricted

at the septum. These septate spores are larger than the others — commonly 3.5 x 12–14 μ. Frequently, the non-septate spores predominate to such an extent that the fungus might readily pass for a species of Phyllosticta, but undoubtedly it is properly referable to the genus Ascochyta. It may be an undescribed species. *Ascochyta medicaginis* Bres.[66] on *Medicago lupulina* has larger spores and pycnidia; so has *Ascochyta pisi* Lib. which is reported as occurring on alfalfa in Denmark.[67] *Ascochyta medicaginis* Fuckel,[68] found on living leaves of *Medicago sativa* and *M. falcata* in Germany, is a synonym of *Phyllosticta medicaginis* (Fckl.) Sacc.[69] the spores of which are described as very small and the pycnidia black. It is unlikely to be *Ascochyta caulicola* Laub.[70] which attacks the stems and petioles of *Melilotus alba*.

When the Ascochyta was first discovered (October, 1907) it was thought to be identical with the *Diplodina medicaginis* Oud. previously found on dead alfalfa stems in early spring (see page 237); but after careful comparison of the two fungi we have reached the conclusion that they are distinct. The spores of the two species are strikingly alike except in one respect, viz., the spores of *D. medicaginis* are commonly biguttulate while those of the Ascochyta are rarely so. The pycnidia of *D. medicaginis* are somewhat larger than those of the Ascochyta and black, while those of Ascochyta are light brown. So far as observed neither the Diplodina nor the Ascochyta attack living alfalfa stems.

There is no reason to believe that the Ascochyta leaf spot will become a troublesome disease.

STAGONOSPORA LEAF SPOT.

(*Stagonospora carpathica* Bäuml. ?)

While examining one of the Station alfalfa fields June 9, 1908, the writers found a leaf spot disease not previously observed. The following day the same disease was found in another field near Geneva. In neither case was the disease sufficiently abundant to cause appreciable damage, yet affected leaves were so common that several hundred specimens were collected in a short time.

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[66] Bresadola (7).
[67] Rostrup (84), (85).
[68] Fuckel (34).
[69] Saccardo (86, 3:42).
[70] Saccardo (86, 18:336).

Unlike the Ascochyta leaf spot, this disease attacks chiefly green leaves in the upper part of the plant. The spots are circular, one to three millimeters in diameter and usually light brown with a narrow border of dark brown. (See Plate XXVI, fig. 4.) Each spot bears several light brown pycnidia visible on both surfaces of the leaf. The pycnidia closely resemble those of the Ascochyta described above except that they are somewhat larger, usually 180 μ in diameter. In water the spores escape through the ostiolum in a gelatinous rope-like mass. The spores are hyaline, straight or slightly curved, rounded at the ends and measure 14–28 x 4 μ the most common size being 20–21 x 4 μ. In most cases the spores appear non-septate. However, septate spores occur abundantly in the more mature pycnidia which may be distinguished by their darker color and especially by the whitening of the leaf tissue at the center of the spot on which they are seated. The number of septa varies from one to four, being usually three. Frequently, slight constrictions occur at the septa.

We have been unable to find any account of an alfalfa disease like this one. However, there is a very similar leaf spot of sweet clover, *Melilotus alba,* caused by *Stagonospora carpathica* Bäuml. the description[71] of which agrees quite closely with the characters possessed by our fungus. We should not hesitate to refer the alfalfa fungus to this species but for the fact that numerous sweet clover plants growing among the affected alfalfa plants were entirely free from the disease.

This leaf spot is readily distinguished from the Ascochyta leaf spot and Cercospora leaf spot (next to be described) by the dark brown border surrounding the spots.

CERCOSPORA LEAF SPOT.

(*Cercospora medicaginis* E. & E.)

A Cercospora on alfalfa foliage was found but once, viz., on June 12, 1908. Only occasional leaves were affected. The Cercospora spots occurred chiefly on green leaves about half way up the plant. They were mostly circular with indefinite outline, smoke-colored or nearly black, 1.5 to 2.5 millimeters in diameter and visible on both surfaces of the leaf. (See Plate XXVI, fig. 3.) The spores measured 40–135 x 4 μ and were 6- to 15-septate. Both in gross appearance and in microscopic characters our specimens agree

[71] Saccardo (86, 10:334).

closely with those distributed in Ellis and Everhart's Fungi Columbiani, Century 24, No. 2314, under the name *Cercospora medicaginis* E. & E. Probably our fungus is referable to this species.[72] However, other names have been given to Cercosporas occurring on alfalfa. In Delaware, Chester[73] found one which he described under the name *Cercospora helvola* Sacc. var. *Medicaginis* Chester. Voorhees[74] mentions the occurrence of *Cercospora helvola* on alfalfa in New Jersey. Frank[75] gives *Medicago sativa* as one of the hosts of *Cercospora helvola*. Saccardo[76] includes *C. medicaginis*, but not *C. helvola*, in the list of fungi occurring on alfalfa.

Apparently, there is no previous record of a Cercospora on alfalfa in New York.

ALTERNARIA DISEASE (?) OF ALFALFA SEED.

A few years ago Dr. Peglion,[77] an Italian investigator, announced that dead, brown seeds of alfalfa and red clover are commonly infested with a certain fungus the hyphæ of which penetrate the seed coat. He found that under temperature and moisture conditions favorable to germination such seeds, instead of germinating, soon become overgrown with a dark-colored mold, *Alternaria tenuis*. This is said to occur even when the seeds have been previously sterilized externally. The perithecial form of the fungus was found and identified as *Pleospora alternariae* Griff. & Gib.

Our observations indicate that the alfalfa seed offered for sale in New York is, likewise, quite generally infested with Alternaria. Most of the samples of alfalfa seed received for examination at the Station have shown a greater or less number of dead, brown, shriveled seeds. In germination tests many of these brown seeds become moldy and in the great majority of cases the mold is of the same kind, viz., a species of Alternaria.[78]

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[72] *Cercospora medicaginis* was originally described on *Medicago denticulata*. See Ellis and Everhart (25).

[73] Chester (13).

[74] Voorhees (104, p. 155).

[75] Frank (30, 2:352).

[76] Saccardo (86, 13:711).

[77] Peglion (76).

[78] Mr. L. Knudson, now of the Department of Plant Physiology in the New York State College of Agriculture, informs us that, in 1907, while an assistant in the Department of Agromony at the Missouri Experiment Station, he made a large number of germination tests of alfalfa and red clover seed and observed that the brown seeds which fail to germinate usually become infested with a species of Alternaria.

This happens even when the seeds have been sterilized on the outside and the germination apparatus also sterilized, as in the following exepriment: From each of twenty samples of alfalfa seed sent to the Station from as many different places in the State, ten brown, shriveled seeds were selected. The 200 seeds thus obtained were divided into two lots of 100 seeds each in such manner that the two lots were exact duplicates, each of them containing five seeds from each of the twenty original samples. One lot (I) of the seeds was soaked 45 minutes in a 1-1000 corrosive sublimate solution to sterilize them externally. By means of sterile forceps the seeds were then transferred to a Geneva seed-tester[79] previously steam sterilized.[80] The other lot (II) of seeds, unsterilized, was placed in the seed-tester at the same time for a check. The temperature to which the seeds were exposed varied from about 16° to 23° C. At the end of nine days the condition of the seeds was as follows: Lot I (sterilized): 26 germinated, 30 moldy, the fungus being Alternaria in 25 cases; Lot II (check): 31 germinated, 34 moldy, the fungus being Alternaria in 28 cases. Seemingly, external sterilization of the seeds does not greatly reduce the tendency to mold.

What relation the Alternaria bears to the seed — whether that of a parasite or merely a saprophyte — can not be stated. Neither was it determined to what species the Alternaria belongs. Usually, it is quite black and produces multitudes of spores.

A molding and rotting of alfalfa seed in Colorado has been discussed by Headden,[81] but he gives no clue to the identity of the fungi concerned in the trouble.

FROST BLISTERS ON ALFALFA LEAVES.

The usual effect of frost on alfalfa leaves is to cause them to become blistered on the lower surface through the separation of the epidermis from the parenchyma. This has been described previ-

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[79] For a description of the Geneva seed-tester see Rpt. of this Station, 2(1883):67; also in *Bot. Gaz.* 10:425.

[80] The copper body of the seed-tester and the cloth pockets which hold the seeds were placed in an autoclave for twenty minutes at a temperature of about 120° C. and a pressure of fifteen pounds. After the apparatus had been put together it was placed over a gas flame for two hours to complete the sterilization.

[81] Headden (41, p. 13).

ously by Noack.[82] The writers have observed it in New York, frequently.

About April 1, 1907, at Geneva, there were a few days of unseasonably warm weather during which alfalfa started into growth and put out new leaves. Then there came a hard freeze. Some of the new leaves were killed outright. Many others were seemingly uninjured; but an examination of them showed that over large areas on the lower surface the epidermis was separated from the parenchyma so that it could be removed readily. Sometimes the loosened epidermis was shiny, but more often it was simply a lighter shade of green than normal.

After heavy frosts (28° F.) occurring May 11 and 12, 1907, alfalfa showed no material injury on May 13. However, many of the leaves were partially wilted, somewhat wrinkled and gray-green, with the epidermis on the lower surface plainly separated from the parenchyma. In some cases the loosened epidermis was ruptured.

By May 4, 1908, alfalfa on the Station farm had made a new growth about five inches high. Although the plants were not materially injured almost every leaf showed large frost blisters on the lower surface. The younger leaves were gray-green and slightly wilted as a result of the light frosts of May 1 and 4 when the minimum temperature was 30° F. in both cases. The older leaves were considerably wrinkled and distorted and often showed ruptures in the loosened epidermis. Their injury was due probably to the hard freeze of April 21 when the temperature went down to 20° F.

INSECT ENEMIES.

The insect enemies of alfalfa have not been included in this investigation. All that can be said on the subject is that we have seen in New York no instance of serious injury to alfalfa caused by insects.

ROOT-KNOT.

Alfalfa root-knot disease caused by nematodes is of frequent occurrence in New York. This first came to our attention in August, 1907, when a newly-seeded field of alfalfa near Geneva was found to be thoroughly infested. Subsequently, the same trouble was observed in many fields in various parts of the State. However, the damage done by it seems to be small.

Root-knot is a very appropriate name for the trouble. It is char-

[82] Noack (72).

acterized by clusters of rootlets which spring from small knots or enlargements on the lateral roots. (Plate XXVII, figs. 1, 3, and 4.) An examination of the surface of the knots with a hand lens reveals certain rounded elevations which are either whitish and glistening or else pale yellow and dull. These are pear-shaped, gravid female nematodes and they are so thoroughly imbedded in the root that they appear to be a part of it. However, with the aid of a dissecting needle they may be dislodged readily. Under the compound microscope they are seen to contain large numbers of eggs or of young larvæ. (Plate XXVII, figs. 3, 5 and 6.)

The nematode in question is referable to the species *Heterodera radicicola* (Greeff) Müll. which is a common and often destructive root parasite of many kinds of plants.[83] In New York, it is injurious chiefly to plants grown under glass. We believe this to be the first published record of the occurrence of a nematode disease of alfalfa in the United States. However, Dr. Ernst Bessey of the University of Louisiana informs us that, according to his observations, alfalfa in this country is often attacked by nematodes. Its occurrence, in Germany has been reported by Frank,[84] and in Egypt, by Mosseri.[85]

The root knots or enlargements caused by nematodes are readily distinguished from bacterial nodules by the fact that the former bear one to several short rootlets each, while the latter are entirely free from them.

DISEASES OF UNKNOWN CAUSE.

WHITE SPOT.

In this disease the leaves are thickly covered with light-colored spots or areas which give the affected plants a whitish appearance. The white spots are irregular in shape, rather definite in outline, .5 to 1.5 millimeters across and usually distributed irregularly although sometimes the distal two-thirds of the leaflet is thickly covered with spots while the proximal one-third is almost entirely free from them. The affected plants are scattered here and there through the field. It is a common thing to find plants so much affected that almost every leaf shows the spots without a trace of disease appearing on any of the surrounding plants.

This disease occurs in alfalfa fields all over the State, but we

[83] Atkinson (1); Stone and Smith (101).
[84] Frank (29), (31), (30, 3:23).
[85] Mosseri (71).

have never seen it sufficiently abundant to cause appreciable loss. It is usually seen in May and June.

The cause of white spot is entirely unknown. The affected leaves show no evidence of being attacked by fungi and it seems unlikely that the trouble is due to insects. It is considerably different from the work of the four-lined leaf-bug (*Poecilocapsus lineatus*) which occasionally attacks alfalfa leaves producing small, translucent spots. Probably it is a physiological disorder of some kind. The roots of affected plants generally appear normal.

YELLOW TOP.

During the past two years one of the Station alfalfa fields, seeded in 1904, has turned bright yellow from an unknown cause. In 1907 this occurred two to three weeks after the second cutting when the plants were seven to nine inches high. It commenced on a strip along one side of the field where the hay had been cut a few days earlier than on the remainder of the field. Ultimately, an area of about two acres became involved. In the spring of 1908 the affected field was entirely normal in color and the first cutting of hay was a heavy crop; but the second and third cuttings were both very yellow and the yield light. This year the trouble started in the same place as in 1907 and spread over the entire field of about four acres. It also appeared, in a mild form, in two other fields on the Station farm. Several fields in the vicinity of Geneva were affected and reports of the disease were received from various other places in the State. It appears to have been not uncommon in 1908.

On affected plants, the lower leaves are green while the upper ones are more or less yellow or, occasionally, purple. As a rule, the yellowing is much more pronounced on the distal than on the proximal portion of the leaflets. Although the yellow leaves do not fall the growth of the plants is severely checked.

There is no reason to believe that this disease is caused by any fungus, insect or other parasite working in the parts of the plant above ground. Plainly, the cause is to be sought underground. Our investigation of the roots of affected plants has been too superficial to warrant positive statements concerning their condition. We can only say that from casual observation they appear to be normal.

Apparently, climatic conditions have something to do with the disease. Dry weather seems to favor it. Both in 1907 and 1908 it made its appearance during very dry weather. However, alfalfa growing in soil containing an excess of moisture frequently shows

a somewhat similar yellowing of the foliage. So far as our observations go, the character of the soil has no marked influence. In the affected field on the Station farm the soil is clay loam, with good surface- and under-drainage. Alfalfa has been grown successfully on this field during the greater part of the past fifteen years without any previous trouble of this kind so far as can be learned.

Yellow top is sometimes mistaken for leaf spot. Although both diseases cause the foliage to turn yellow the two should be distinguished without difficulty. Plants affected with yellow top show green leaves below and yellow leaves above; whereas those affected with leaf spot have yellow leaves below and green leaves above. Besides, in yellow top the leaves are free from spots and do not fall; while in leaf spot the leaves are thickly covered with small brown spots and fall prematurely. Of course, the two diseases may occur together.

A disease which may have been yellow top is said by Elliott[86] to have greatly shortened the yield of alfalfa hay in Washington in 1906.

PITTING OF THE TAP-ROOT.

The tap-roots of alfalfa plants in this State are quite commonly covered with brown pits and scars of various shapes and sizes. On the roots of old plants the scars are suggestive of the potato scab disease and one might easily believe that they are due to the attack of some parasitic fungus; but on the roots of plants one and two years old it is plain to be seen that the bark has been gnawed by some insect or animal. (Plate XXVII, fig. 2) Although the growth of the plants does not appear to be seriously checked the effect of the pitting cannot be otherwise than harmful. In the aggregate, the damage done must be considerable, for the trouble is exceedingly common.

BUNDLE BLACKENING IN THE TAP-ROOT.

Black or brown streaks within the tap-root are of frequent occurrence. The black streaks are discolored fibro-vascular bundles. The cause of the discoloration is unknown. So far as can be determined from microscopic examination neither bacteria nor fungi are to be found in the blackened bundles. Whether the bundle blackening indicates a diseased condition of the tap-root cannot be definitely stated. It often occurs in the roots of thrifty, apparently healthy plants.

[86] Elliott (27, p. 31).

DISEASES NOT KNOWN TO OCCUR IN NEW YORK.

For the convenience of those who may wish to pusue the subject further there is given here a brief account of the various other diseases said to affect alfalfa but which have not yet been observed in New York.

FUNGUS DISEASES.

Violet root-rot (*Rhizoctonia medicaginis* DC.)[87] kills the alfalfa in circular spots several feet in diameter. It is a destructive disease common in Europe.[88] In this country it seems to be rare, although Freeman reports it troublesome in Kansas.[89]

Brown root-rot is a disease having symptoms similar to the preceding but caused by a different fungus, viz., *Ozonium omnivorum* Shear.[90] It occurs in Texas,[91] Arizona[92] and Kansas.[93]

A Fusarium root-rot has been reported from Arizona.[94]

Sclerotinia trifoliorum Eriks. which causes root-rot of clover is said to attack also alfalfa.[95] Duggar[96] observed a sclerotial root disease (fungus not determined) of alfalfa in Alabama.

Urophlyctis alfalfae (Lagerh.) Magn. produces galls on the roots near the crown of the plant. It occurs in Ecuador,[97] Europe[98] and England,[99] but has not been observed in the United States.

Rust (*Uromyces striatus* Schroet.) on the leaves is an unimportant disease of wide distribution.[100] Another rust (*Uredo medicaginicola* Speg.) is said to occur on the stems of alfalfa in South America.[101]

Other fungi parasitic on alfalfa leaves are the following: *Gloe-*

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[87] De Candolle (23).

[88] Prunet (82); Wagner (105); Prillieux (80, 2:144); Frank (30, 2:515); Briosi and Cavara (8, No. 225).

[89] Freeman (32).

[90] Shear (94).

[91] Curtis (20).

[92] Toumey (103); Thornber (102).

[93] Freeman (32).

[94] McCallum (63).

[95] Prillieux (80, 2:419); Massee (65, p. 155); Coleman (16).

[96] Duggar (24, p. 41).

[97] von Lagerheim (59).

[98] Magnus (64).

[99] Salmon (88).

[100] Freeman (32), Briosi and Cavara (8, No. 4).

[101] Saccardo (86, 16:351).

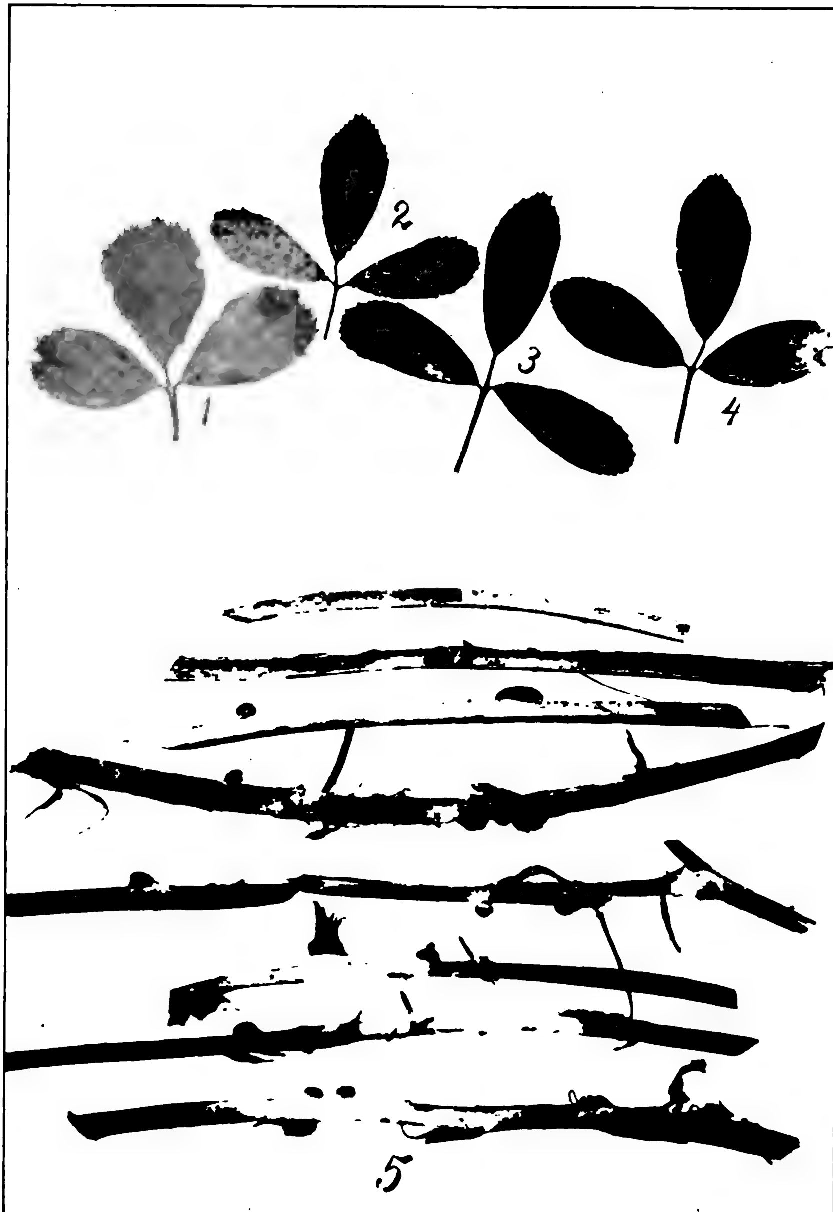
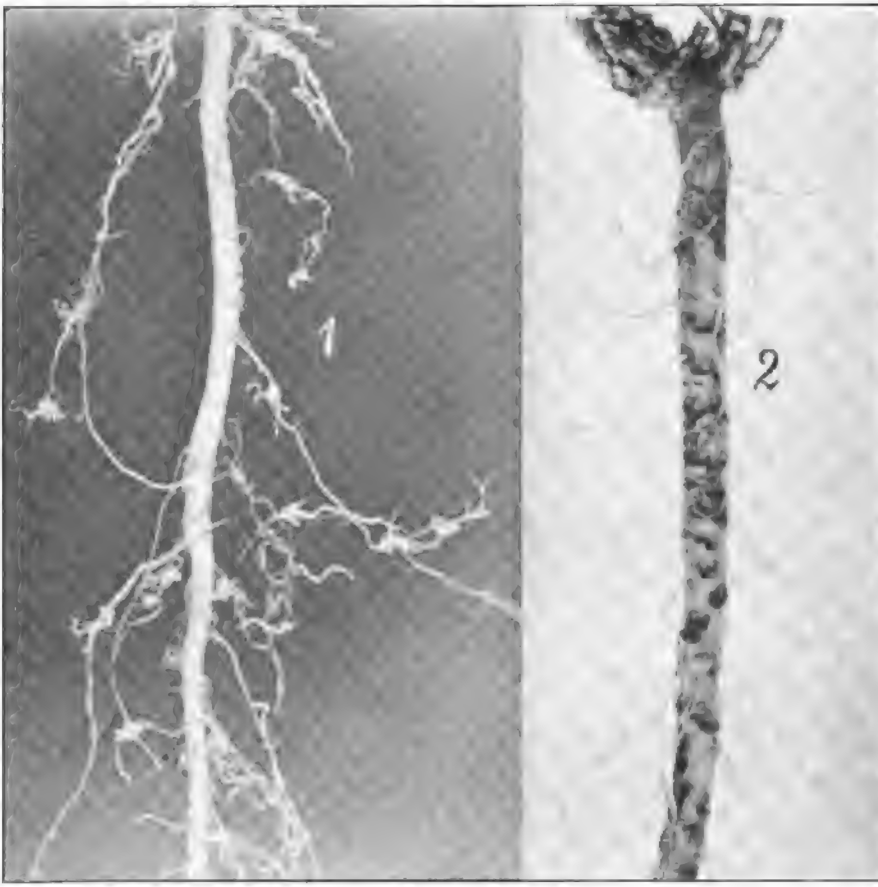


PLATE XXVI.— SOME FUNGUS DISEASES OF ALFALFA.

1, Ascochyta leaf spot (*Ascochyta sp.*); 2, Leaf spot (*Pseudopeziza medicaginis*); 3, Cercospora leaf spot (*Cercospora medicaginis*); 4, Stagonospora leaf spot (*Stagonospora carpathica*); 5, alfalfa stems attacked by *Sclerotinia libertiana*. Two stems at top split to show sclerotia formed within.

(All figures natural size.)



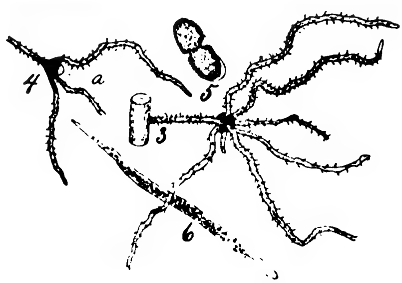


PLATE XXVII. — TWO ROOT TROUBLES OF ALFALFA.

1, Root-knot caused by nematodes; 2, pitting of the tap-root; 3, portion of tap-root and lateral root with a root-knot; 4, a root-knot showing gravid female nematode at *a;* 5, nematode egg; 6, young nematode.

(1 and 2 natural size; 3 and 4, magnified 2 diameters; 5 and 6, magnified 95 diameters.)

osporium medicaginis Ell. & Kell.,[102] *Gloeosporium morianum* Sacc.,[103] *Pleosphaerulina briosiana* Pollacci,[104] *Macrosporium medicaginis* Cugini,[105] *Erysiphe polygoni* DC.,[106] *Phyllosticta medicaginis* (Feckl.) *Sacc.*,[107] *Septoria medicaginis* Rob. & Desm.,[108] *Ascochyta pisi* Lib.,[109] *Cercospora helvola* Sacc.,[110] *Laestadia destructiva* (Berk. & Br.) Berl. & Vogl.[111]

BACTERIAL DISEASE.

Paddock[112] has given a brief account of a supposedly bacterial root disease of alfalfa occurring in Colorado.

PHANEROGAMIC PARASITES.

Several species of dodder (Cuscuta) have been recorded as attacking alfalfa stems. How many of them occur in New York is not known. (See page 198.)

There are also a few phanerogamic root-parasites. Nobbe[113] states that three species of Orobanche, viz., *O. buekiana* Koch, *O. rubens* Wallr. and *O. minor* Sutt., are parasitic on alfalfa in Germany. Lignier[114] includes *Medicago sativa* in the list of host plants of *Thesium divaricatum* var. *humifusum* A. DC.

INSECTS, NEMATODES AND OTHER ANIMAL ENEMIES.

Having given but little attention to the insects affecting alfalfa,[115] the writers are unable to enumerate the species occurring in New York.

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[102] Ellis and Kellerman (26).

[103] Saccardo (86, 10:458); Frank (30, 2:380). Saccardo (Syll. Fung. 18:449) gives *Medicaggo sativa* as the host of *Glœosporium caulivorum* Kirch. This seems to be an error. The only host given by Kirchner (*Ztschr. Pflanzenkrank.* 12:10) is *Trifolium pratense.*

[104] Pollacci (79); Briosi and Cavara (8, No. 383); Saccardo (86, 16:554).

[105] Saccardo (86, 18:618).

[106] Salmon (87, p. 180); Prillieux (80, 2:14).

[107] Saccardo (86, 3:42).

[108] Saccardo (86, 3:508); Frank (30, 2:431).

[109] Rostrup (84), (85).

[110] Frank (30, 2:350); Voorhees (104, p. 155).

[111] McAlpine (62, p. 127).

[112] Paddock (74).

[113] Nobbe (73, p. 470). See also Caspay (12) and Koch (56).

[114] Lignier (60).

[115] For an account of the insects injurious to alfalfa see Bruner and Hunter (10); or Headlee (42).

In Europe,[116] the nematode, *Tylenchus devastatrix* Kühn, attacks alfalfa stems causing a disease which the Germans call "Stockkrankheit." It is not known to occur in America.

Other animals reported troublesome in alfalfa fields are the woodchuck,[117] prairie dog,[118] pocket gopher[119] and ground squirrel.[120] Only the first mentioned of these is found in New York.

LIGHTNING.

Sitensky[121] cites an instance in which a bolt of lightning killed alfalfa plants over a circular area five meters (about sixteen feet) in diameter.

SPONTANEOUS COMBUSTION.

It appears to be an established fact that alfalfa hay stored in stacks and barns may become so hot as to take fire through spontaneous combustion. Several examples are given by Cottrell[122] who states that all of the cases coming under his observation occurred with hay from the first cutting. Doubtless spontaneous combustion of alfalfa occurs in New York, but no clear case of it has come to our attention.

SAPROPHYTIC FUNGI ON ALFALFA.

Our studies on the saprophytic fungi have been too fragmentary to enable us to give anything like a complete list of the species occurring on alfalfa in New York. Only a few species have been given more than passing attention. However, it is desirable to have before us a list of the fungi saprophytic on alfalfa. Upon further investigation some of the species now classed as saprophytes may prove to be parasites or, perhaps, genetically related to parasitic species. Accordingly, the following list of alfalfa saprophytes is appended. It is compiled mainly from Saccardo's Sylloge Fungorum. The species starred have been observed in New York by the writers.

* *Alternaria* sp. On stems.
* *Coniothyrium* sp. On stems and stipules.
* *Dendrodochium* sp. On stems and roots. (See page 221).

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116 Frank (30, 3:29).
117 Wing (112, p. 39).
118 Cottrell (19, p. 78); Coburn (15, p. 212).
119 Scheffer (89, p. 124); Headlee (42).
120 Elliott (27, p. 31).
121 Sitensky (95).
122 Cottrell (18), (19, p. 67).

**Didymium difforme* (Pers.) Duby. On stems.
Diplodia elæospora Sacc. On stems. Syll. Fung. 3:369.
D. medicaginis Brun. On stems. Syll. Fung. 10:289.
**Diplodina medicaginis* Oud. On stems. Syll. Fung. 18:351.
**Fusarium* sp. On stems and roots. (See page 221).
**Haplographium toruloides* (Fres.) Sacc. On stems. *Rabh. Krypt. Flora.* Bd. I., Abt. 8:696.
Hendersonia circinans Sacc.[123] On root and stems. Syll. Fung. 3:431.
Læstadia insidiosa Massee. On leaves. Syll. Fung. 17:574.
Leptosphæria circinans (Fckl.) Sacc. On roots. Syll. Fung. 2:88.
L. medicaginis (Fckl.) Sacc. On stems. Syll Fung. 2:19.
L. medicaginum Sacc. On stems. Syll. Fung. 2:35.
L. pratensis S. & Br. On stems. Syll. Fung. 9:768.
Leptothyrium medicaginis Pass. On stems. Syll. Fung. 3:634.
L. vulgare (Fr.) Sacc. On stems. Syll. Fung. 13:711.
**Macrosporium commune* Rbh. On leaves.
Melanomma dubiosum Sacc. On stems. Syll. Fung. 13:711.
Microdiplodia medicaginis Diedicke. On stems. Syll. Fung. 18:325.
Orbilia medicaginis Fautr. & Roun. On stems. Syll. Fung. 11:426.
Phoma anceps Sacc. On stems. Syll. Fung. 3:120.
P. herbarum West. On stems. Syll. Fung. 3:133.
P. roseola Desm. On roots. Syll. Fung. 11:489.
P. vulgaris Sacc. On stems. Syll. Fung. 3:119.
**Pionnotes rhizophila* (Cda.) Sacc. On roots. Syll. Fung. 13:712.
Pleospora herbarum (Pers.) Rabh. On stems. Syll. Fung. 13:712.
Pyrenochæta penicillata Fckl. On stems. Syll. Fung. 3:220.
Rhabdospora allantoidea (B. & C.) Sacc. On stems. Syll. Fung. 3:586.
**Torula* sp. On stems.
Trichopeziza sulphurea (Pers.) Fckl. On stems. Syll. Fung. 13:712.
**Volutella gilva* (Pers.) Sacc. On stems. Syll. Fung. 13:712.

One of the species listed above, *Diplodina medicaginis*, was given considerable study. An alfalfa field at Geneva seeded in the spring of 1906 went into its first winter with a growth about a foot in height. The following March the dead alfalfa stems (which were still standing upright) were thickly covered with the black pycnidia of *Diplodinia medicaginis*. A similar condition was found in several other alfalfa fields. The fungus appears to be an exceedingly abundant one.

The pycnidia are erumpent, membranous, distinctly ostiolate and 100 to 200 μ in diameter. On March 26 mature spores were abundant. When the pycndia are placed in water the spores exude through the ostiolum in rope-like masses. The spores are hyaline, 10–17 x 3–4 μ, straight or slightly curved, rounded at the ends and

[123] According to Fuckel (*Bot. Ztg.* 1861, p. 251 and Symb. Myc. p. 142) *Hendersonia circinans* is the pycnidial form and *Leptosphæria circinans* the ascigerous form of *Rhizoctonia megicaginis* DC.

usually bi-guttulate. Many of the spores are apparently non-septate. The majority of them are slightly constricted at the middle and many are certainly once-septate, but it is often difficult to make out the septum. Sometimes one of the cells is a little broader than the other.

The Diplodina grows readily on ordinary culture media such as sterilized plugs of sugar-beet and acidulated potato agar. On sugar beet the growth soon becomes black with enormous numbers of pycnidia which are filled with multitudes of spores.

This fungus closely resembles the Ascochyta occurring on alfalfa leaves but it is certainly a different species. (See page 225.)

MISCELLANEOUS.

AN ALFALFA PLANT WITH UNFOLIATE LEAVES.

In alfalfa, the first leaf after the seed-leaves consists of a single leaflet while the succeeding ones are pinnately trifoliate.[124] (See Plate XXI.) Recently, the writers found an alfalfa plant having unifoliate leaves throughout. There being, apparently, no published record of such a freak alfalfa plant it is thought worth while to give an account of it here.

The plant was discovered among some alfalfa seedlings grown in the Station greenhouse during the spring of 1907. It grew in a flower pot in the greenhouse until the spring of 1908 when it was transplanted into the open garden together with four other plants propagated from it by cuttings. At the present writing (October, 1908) all five plants are in fairly normal condition. In general appearance they are similar to normal alfalfa plants. None of them have never shown anything but the unifoliate leaves which are of the same size, shape and appearance as the terminal leaflet in ordinary trifoliate leaves. The plants have flowered only sparingly and produced no seed. They have been affected with leaf spot (*Pseudopeziza medicaginis*), and *Diplodina medicaginis* appeared on some of the dead stems in October, 1907.

MULTIPLICATION OF LEAFLETS.

We have occasionally seen alfalfa leaves with four and five leaflets.

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[124] The same is true of other species of Medicago, Trifolium and some other Leguminosæ. (See Lubbock, Sir John. A contribution to our knowledge of seedlings. 1:388).

WHITE FLOWERS OF ALFALFA.

Westgate[125] describes alfalfa flowers as "purple, rarely white." The writers have seen many alfalfa flowers which were nearly white, but only one plant which produced pure white flowers. Percival's statement[126] that the flowers of *Medicago sativa* are sometimes yellow is probably an error.

DO ALFALFA ROOTS CLOG TILE DRAINS.

It is said that tile drains are sometimes clogged by alfalfa roots. The writers have heard of a few such cases in New York, but have never seen one. On this subject, J. E. Wing of Mechanicsburg, Ohio, says:[127] "We find that where the tile runs to a spring with running water the year around the tile will become choked with alfalfa roots every four or five years, but where there is only the ordinary surface water to take care of there will be no trouble from roots choking the tile."

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[125] Westgate (107).
[126] Percival (78).
[127] Wing (113).

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POTATO SPRAYING EXPERIMENTS IN 1907.*

F. C. STEWART, G. T. FRENCH AND F. A. SIRRINE.

SUMMARY.

This bulletin gives the results of the sixth year's work in the ten-year series of potato spraying experiments begun in 1902. During 1907 the experiments were conducted along the same lines as in previous years. Forty separate experiments are reported.

TEN-YEAR EXPERIMENTS.

At Geneva five sprayings increased the yield 73.7 bu. per acre and three sprayings increased it 44 bu. notwithstanding the fact that the amount of damage done by blights and insects was seemingly small. There was no rot. At Riverhead the gain due to six sprayings was 31.25 bu. per acre and to three sprayings 18 bu. Here, the chief enemies were the flea beetle and early blight.

FARMERS' BUSINESS EXPERIMENTS.

In fourteen farmers' business experiments, including 152.75 acres, the average gain due to spraying was 36.8 bu. per acre; the average total expense of spraying, $5.90 per acre; and the average net profit, $17.07 per acre.

VOLUNTEER EXPERIMENTS.

Twenty-four volunteer experimenters reported gains averaging 30.5 bu. per acre.

The chief troubles of potatoes in New York in 1907 were flea beetles and dry weather. The experiences of 1907 do not warrant any material alteration in the recommendations for spraying made in Bulletin 290.

*A reprint of Bulletin No. 307.

INTRODUCTION.

Does it pay to spray potatoes in New York? Potato growers have been asking this question for fifteen years or more. It is well known that in seasons when blight is destructive spraying will check the blight and considerably increase the yield; but the majority of potato growers have doubted that spraying is profitable on the average. They argue that blight does not appear every year. In some seasons it causes but little if any damage; yet the spraying must be done regularly because it is impossible to foretell the appearance of blight. The result is that in some seasons spraying is profitable while in others it is unprofitable; and these growers doubt that the aggregate gain in yield for a series of years will more than pay the expense of annual spraying.

This Station has set out to find an answer to the above question. The investigation was begun in 1902 and is to be continued until 1912. During ten consecutive years numerous potato spraying experiments will be made each year and at the end of the period the results will be averaged. The experiments are of three kinds: (1) Station ten-year experiments; (2) farmers' business experiments; (3) farmers' volunteer experiments. The ten-year experiments (two each year) are carried out entirely by the Station. The business experiments (13 to 15 each year) are conducted by farmers in co-operation with the Station. The volunteer experiments are carried out entirely by farmers.

Bulletins previously published are:

No. 221. Potato Spraying Experiments in 1902;
No. 241. Potato Spraying Experiments in 1903;
No. 264. Potato Spraying Experiments in 1904;
No. 279. Potato Spraying Experiments in 1905;
No. 290. Potato Spraying Experiments in 1906.

SUMMARY OF RESULTS OBTAINED IN TEN-YEAR EXPERIMENTS PRIOR TO 1907.

RESULTS IN 1902.

TABLE I.—YIELD BY SERIES AT GENEVA IN 1902.

SERIES.	Rows.†	Dates of spraying.	Yield per acre.*	
			Bu.	*lbs.*
I.....	1, 4, 7 and 13...	July 10, 23 and August 12..................	317	41
II.....	2, 5, 8 and 14...	June 25, July 10, 23, 30, August 12, 26 and September 10..........................	342	36
III.....	3, 6, 9 and 15...	Not sprayed............................	219	4

† Rows 10, 11 and 12 omitted because of probable error.
* The yields given in Tables I to X relate to marketable tubers only.

Gain due to spraying three times, 98½ bu. per acre.
Gain due to spraying seven times, 123½ bu. per acre.

The unsprayed rows died two weeks earlier than the sprayed rows, owing chiefly to a severe attack of late blight. They were also somewhat injured by flea beetles, but there was no early blight. On unsprayed rows the loss from rot was 7½ per ct.; on sprayed rows only an occasional tuber.

TABLE II.— YIELD BY SERIES AT RIVERHEAD IN 1902.

SERIES.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	2, 5, 8 and 11...	May 26, June 20 and July 12..............	295	20
II.....	1, 4, 7 and 10...	May 26, June 3, 20, 30, July 11, 23 and Aug. 5.	312	35
III.....	3, 6, 9 and 12...	Not sprayed............................	267	40

Gain due to spraying three times, 27⅔ bu. per acre.
Gain due to spraying seven times, 45 bu. per acre.

In this experiment there were only traces of early blight and no late blight. The larger yield on sprayed rows was due to partial protection against flea beetles which were rather plentiful at times. There was no rot.

RESULTS IN 1903.

TABLE III.— YIELD BY SERIES AT GENEVA IN 1903.

SERIES.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13.	July 14, 28 and August 26.................	262	—
II.....	2, 5, 8, 11 and 14.	July 7, 21, August 7, 21 and September 3....	292	10
III.....	3, 6, 9, 12 and 15.	Not sprayed............................	174	20

Gain due to spraying three times, 88 bu. per acre.
Gain due to spraying five times. 118 bu. per acre.

Three sprayings prolonged the life of the plants 11 days; five sprayings 18 days. There was no early blight and the injury from flea beetles was only slight. Late blight was again the chief enemy. The loss from rot was even less than in 1902.

TABLE IV.— YIELD BY SERIES AT RIVERHEAD IN 1903.

SERIES.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7 and 10...	June 5, July 22 and August 7..............	246	45
II.....	2, 5, 8 and 11...	June 5, 24, July 7, 22 and August 7.........	263	10
III.....	3, 6, 9 and 12...	Not sprayed............................	207	10

Gain due to spraying three times, 39½ bu. per acre.
Gain due to spraying five times, 56 bu. per acre.

The sprayed rows outlived those unsprayed by several days. Late blight and flea beetles were the chief enemies. Early blight, also, caused slight damage. On the unsprayed rows the loss from rot was two per ct.; on those sprayed, practically nothing.

RESULTS IN 1904.

TABLE V.— YIELD BY SERIES AT GENEVA IN 1904.

SERIES.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7, 10 and 13.	July 13, 27 and August 15................	344	30
II.....	2, 5, 8, 11 and 14.	July 8, 22, August 1, 15 and 29............	386	40
III.....	3, 6, 9, 12 and 15.	Not sprayed............................	153	25

Gain due to spraying three times, 191 bu. per acre.
Gain due to spraying five times, 233 bu. per acre.

Spraying prolonged the life of the plants 25 days. Late blight was the only trouble. In both sprayed and unsprayed rows there was a little rot at digging time. In storage, the sprayed potatoes rotted most. Spraying materially improved the cooking qualities.

TABLE VI.— YIELD BY SERIES AT RIVERHEAD IN 1904.

SERIES.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	lbs.
I.....	1, 4, 7 and 10...	June 14, July 21 and August 9.............	257	58
II.....	2, 5, 8 and June	14, 27, July 11, 2 , Aug. 9 and 22..........	297	45
III.....	3, 6, 9 and 12...	Not sprayed............................	201	25

Gain due to spraying three times, 56½ bu. per acre.
Gain due to spraying six times, 96⅓ bu. per acre.

The larger yield on sprayed rows was due chiefly to partial protection against flea beetles which were unusually abundant. Both

early and late blight also present. The loss from rot was three per ct. on Series I. and one per ct. on Series II. and six per ct. on Series III.

RESULTS IN 1905.

TABLE VII.—YIELD BY SERIES AT GENEVA IN 1905.

SERIES.	Rows.†	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	4, 7, 10 and 13..	July 3, August 7 and 25..................	228	45
II.....	5, 8, 11 and 14..	June 29, July 13, 27, August 12 and 24......	241	15
III.....	6, 9, 12 and 15..	Not sprayed............................	121	52

† Rows 1, 2 and 3 omitted because of error.

Increase in yield due to spraying three times, 107 bu. per acre.
Increase in yield due to spraying five times, 119⅓ bu. per acre.

From the combined attack of flea beetles, tip burn and late blight the unsprayed rows died fully two weeks earlier than the sprayed ones. Spraying reduced the loss from rot at the rate of 41 bushels per acre. There was no subsequent rot in storage.

TABLE VIII.—YIELD BY SERIES AT RIVERHEAD IN 1905.

SERIES.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13.	June 14, July 18 and August 11............	253	—
II.....	2, 5, 8, 11 and 14.	June 14, 30, July 14, 28 and August 11......	303	41
III.....	3, 6, 9, 12 and 15.	Not sprayed............................	221	38

Increase in yield due to spraying three times, 31⅓ bu. per acre.
Increase in yield due to spraying five times, 82 bu. per acre.

Late blight caused no injury in this experiment and there was not even a trace of rot. Flea beetles and early blight were the enemies fought.

RESULTS IN 1906.

TABLE IX.—YIELD BY SERIES AT GENEVA IN 1906.

SERIES.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13..	July 9, August 10 and 30................	227	25
II.....	2, 5, 8, 11 and 14	July 6, 20, August 6, 20 and 21............	258	40
III.....	3, 6, 9, 12 and 15.	Not sprayed............................	195	40

Increase in yield due to spraying three times, 31¾ bu. per acre.
Increase in yield due to spraying five times, 63 bu. per acre.

Late blight, early blight, flea bettles and tip burn were all factors in this experiment, but none of them caused much damage. Spraying controlled blight and flea beetles completely and tip burn partially. The loss from rot was negligible, only four rotten tubers being found in the entire experiment.

TABLE X.— YIELD BY SERIES AT RIVERHEAD IN 1906.

SERIES.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13.	June 12, July 18 and August 6.............	172	—
II.....	2, 5, 8, 11 and 14.	June 12, 25, July 10, 25 and August 6.......	203	45
III.....	3, 6, 9, 12 and 15.	Not sprayed..............................	150	30

Increase in yield due to spraying three times, 21½ bu. per acre.
Increase in yield due to spraying five times, 53¼ bu. per acre.

In the experiment at Riverhead the principal enemies were late blight and flea beetles, there being a moderate attack of both. Early blight was not sufficiently abundant to cause material injury. There was no loss from rot.

DETAILS OF THE TEN-YEAR EXPERIMENTS IN 1907.

AT GENEVA.

In 1907, the experiment was carried out in practically the same manner as in previous years. There were 15 rows[4] 290.4 feet long by three feet wide. Planting was done by hand May 22, in drills, the seed pieces being 15 inches apart. The variety was Rural New Yorker No. 2. The soil was heavy clay loam, well drained. The previous crop was clover.

The five rows constituting Series I were sprayed three times— twice with bordeaux mixture and paris green and once with bordeaux alone — the dates being July 15 and 24 and August 9.

The five rows constituting Series II were sprayed five times — twice with bordeaux mixture and paris green and three times with bordeaux mixture alone — the dates being July 15 and 24, August 9 and 24 and September 17.

The five rows constituting Series III (Check) were not sprayed at all with bordeaux mixture, but were treated twice (July 15 and 24) with paris green in lime water to control bugs.

[4] Besides the 15 rows in the experiment proper there were, as in all previous experiments, two other rows which served the purpose of outside rows.

The spraying was done very thoroughly with a knapsack sprayer. The bordeaux mixture used contained six pounds of copper sulphate to each 50 gallons and lime considerably in excess of the amount required to satisfy the potassium ferrocyanide test. Whenever paris green was used it was applied at the rate of one-half pound to 50 gallons of bordeaux or of lime water as the case might be.

Over the entire field bugs were brought under complete control by the two applications of paris green made July 9 and 24. Late blight (*Phytophthora infestans*) was wholly absent and early blight (*Alternaria solani*) appeared only in traces. There was some tip burn and a light attack of flea beetles (chiefly, *Epitrix cucumeris*). Up to September 1 there was scarcely any difference between sprayed and unsprayed rows. But during September a change came about — the unsprayed rows gradually turned brown and died while the sprayed ones remained green. The reason for the longer growth of the sprayed plants is not altogether clear. Probably it was owing chiefly to the fact that the spraying protected the plants against flea beetle injuries. There being an abundance of rain after about September 15 and no killing frost until October 17, the plants remaining alive had an exceptional opportunity for growth. Although planted so early as May 22 the sprayed rows still showed considerable green foliage as late as October 17 when the frost came.

The potatoes were dug by hand. The product of each row was sorted into two grades — marketable tubers and culls — and weighed. No rotten tubers were found. The yields follow:

TABLE XI.— YIELDS IN THE EXPERIMENT AT GENEVA IN 1907.

Row.	Treatment.	Yield per row.		Yield per acre.			
		Marketable.	Culls.	Marketable.		Culls.	
		Lbs.	*Lbs.*	*Bu.*	*lbs.*	*Bu.*	*lbs.*
1....	Sprayed 3 times..............	253	4	210	50	3	20
2....	Sprayed 5 times..............	301	1	250	50		50
3....	Unsprayed....................	202	4	168	20	3	20
4....	Sprayed 3 times..............	238	3	198	20	2	30
5....	Sprayed 5 times..............	290	3	241	40	2	30
6....	Unsprayed....................	202½	4½	168	45	3	45
7....	Sprayed 3 times..............	252½	2	210	25	1	40
8....	Sprayed 5 times..............	301	2½	250	50	2	5
9....	Unsprayed....................	216	5	180	—	4	10
10....	Sprayed 3 times..............	304½	1½	253	45	1	15
11....	Sprayed 5 times..............	303	1	252	30		50
12....	Unsprayed....................	213½	2½	177	55	2	5
13....	Sprayed 3 times..............	273½	1½	227	55	1	15
14....	Sprayed 5 times..............	304	1½	253	20	1	15
15....	Unsprayed....................	223	2½	185	50	2	5

† Rows 290.4 feet long by 3 feet wide making the area of each row exactly one-fiftieth acre

Yield by series.— The five rows sprayed three times constitute Series I and the average yield of these rows makes the yield for Series I. The yields given for Series II and III have been computed in the same manner. The yield by series is shown in the following table:

TABLE XII.— YIELD BY SERIES AT GENEVA IN 1907.

SERIES.	Rows.	Dates of spraying.	Yield per acre.†	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13.	July 15, August 9 and 24..................	220	15
II.....	2, 5, 8, 11 and 14.	July 15, 24, August 9, 24 and September 17..	249	50
III.....	3, 6, 9, 12 and 15.	Not sprayed.............................	176	10

† Marketable tubers only.

Increase in yield due to spraying three times, 44 bu. per acre.
Increase in yield due to spraying five times, 73⅔ bu. per acre.

Considering the seemingly small amount of damage done by insect and fungus pests it is remarkable that spraying should have increased the yield so much.

AT RIVERHEAD.

The experiment at Riverhead is, essentially, a duplicate of the Geneva experiment, differing from it only in minor details. The soil was sandy loam and the previous crop had been potatoes. The rows were 290.4 feet long by three feet wide. Planting was done April 25 with a Robbins potato planter. The variety was Carman No. 1.

The five rows constituting Series I were sprayed three times (June 19, July 25 and August 15) with bordeaux mixture and paris green and treated twice besides (June 29 and July 9) with paris green in lime water.

The five rows constituting Series II were sprayed six times (June 19, July 2, 17, 31, August 15 and 29) with bordeaux mixture. Paris green was used with the bordeaux in the first three spraying and in the fifth one.

The five rows constituting Series III (Check) were not sprayed at all with bordeaux but were treated twice (June 29 and July 16) with paris green in lime water to control bugs.

The bordeaux mixture used was prepared in the same manner as in the Geneva experiment. (See page 250.) Whenever paris green was used it was applied at the rate of one pound to fifty gallons. All of the applications were made with a knapsack sprayer and the work done very thoroughly.

Bugs were numerous and persistent in spite of the frequent use of paris green. However, the unsprayed rows which received only two applications of paris green were but little if any more injured than the sprayed rows of Series I to which paris green was applied five times. We believe this to be due to the fact that the first treatment of the unsprayed rows was made at exactly the right time to get the best results.

There was some early blight, but no late blight. Flea beetles were plentiful and caused much damage. By August 10 there was a striking contrast in appearance between sprayed and unsprayed rows. Series II had twice as much green foliage as Series III. The larger yield of the sprayed rows in this experiment is to be attributed to their partial protection against the ravages of flea beetles and early blight.

The potatoes were dug by hand October 7. The product of each row was carefully sorted into two grades — marketable tubers and culls — and weighed separately. No rotten tubers were found. The yields were as follows:

TABLE XIII.— YIELDS IN THE EXPERIMENT AT RIVERHEAD IN 1907.

Row.	Treatment.	Yield per row.†		Yield per acre.			
		Marketable.	Culls.	Marketable.		Culls.	
		Lbs.	*Lbs.*	*Bu.*	*lbs.*	*Bu.*	*lbs.*
1....	Sprayed 3 times..............	227	17	189	10	14	10
2....	Sprayed 6 times..............	243	21	202	30	17	30
3....	Unsprayed....................	216	22½	180	—	18	45
4....	Sprayed 3 times..............	216	26½	180	—	22	5
5....	Sprayed 6 times..............	235	25	195	50	20	50
6....	Unsprayed....................	211	25½	175	50	21	15
7....	Sprayed 3 times..............	240	21	200	—	17	30
8....	Sprayed 6 times..............	236	22	196	40	18	20
9....	Unsprayed....................	178	24	148	20	20	—
10....	Sprayed 3 times..............	211½	21	176	15	17	30
11....	Sprayed 6 times..............	231	25	192	30	20	50
12....	Unsprayed....................	207	25	172	30	20	50
13....	Sprayed 3 times..............	226	33½	188	20	27	55
14....	Sprayed 6 times..............	255½	23½	212	55	19	35
15....	Unsprayed....................	201	23	167	30	19	10

† Rows 290.4 feet long by 3 feet wide making the area of each row exactly one-fiftieth acre.

TABLE XIV.— YIELD BY SERIES AT RIVERHEAD IN 1907.

Series.	Rows.	Dates of spraying.	Yield per acre.†	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13.	June 19, July 25 and August 15............	186	45
II.....	2, 5, 8, 11 and 14.	June 19, July 2, 17, 31, August 15 and 29.....	200	5
III.....	3, 6, 9, 12 and 15.	Not sprayed..............................	168	50

† Marketable tubers only.

Increase in yield due to spraying three times, 18 bu. per acre.
Increase in yield due to spraying six times, 31¼ bu. per acre.

In all six years during which these experiments have been in progress the gain from spraying at Riverhead has been much smaller than at Geneva. The exact amount of this difference is shown in the next table.

SUMMARY OF RESULTS OBTAINED IN THE TEN-YEAR EXPERIMENTS, 1902–1907.

The following table shows the results obtained in the ten-year experiments during the first six years:

TABLE XV.— SUMMARY OF THE TEN-YEAR EXPERIMENTS FOR SIX YEARS.

YEAR.	AT GENEVA.		AT RIVERHEAD.	
	Gain per acre due to spraying every two weeks.	Gain per acre due to spraying three times.	Gain per acre due to spraying every two weeks.	Gain per acre due to spraying three times.
	Bu.	*Bu.*	*Bu.*	*Bu.*
1902	123½	98½	45	27¾
1903	118	88	56	39½
1904	233	191	96	56½
1905	119	107	82	31¼
1906	63	32	53	21½
1907	73¾	44	31	18
Average	121¾	93½	60½	32½

FARMERS' BUSINESS EXPERIMENTS.

During the season of 1907 fourteen farmers in different parts of the State conducted business experiments in co-operation with this Station. The object of these experiments is to determine the actual profit in spraying potatoes under farm conditions. The methods employed were essentially the same as in previous years. An accurate record was kept of all of the expense of spraying, including labor, chemicals and wear of machinery. In each experiment a strip of three to six rows was left unsprayed for comparison.

In order to bring the account of the experiments within the required space limit it has been necessary to omit many interesting details.

Throughout this bulletin the word "spraying" is used in a restricted sense. It means the application of bordeaux mixture exclusively and not the use of paris green with water.

Whenever "arsenite of soda stock solution" is mentioned it should be understood to mean the stock solution prepared by the Kedzie formula — one pound white arsenic, four pounds sal soda and one gallon of water boiled together 20 minutes.

By "test rows" is meant the rows used for determining the amount of the increase in yield due to spraying. These are, usually, the middle unsprayed row and the second sprayed row on either side.

The yields given are for marketable tubers only.

The price used in computing the value of the increased yield is, in every case, the market price for potatoes in the locality where the experiment was made, on the date on which the test rows were dug.

THE BATAVIA EXPERIMENT.

Conducted by G. A. Prole, Batavia, N. Y. Thirteen acres, variety Sir Walter Raleigh, were sprayed 4 times with a two-horse, home-made sprayer pumped by hand. In the first two sprayings one nozzle per row was used and five rows covered at each passage; in the last two, two nozzles per row and four rows covered. The dates of spraying were July 19, August 8, 23 and September 2. The bordeaux used contained 6 lbs. copper sulphate to 50 gals. water, with sufficient lime added to satisfy the potassium ferrocyanide test. Poison for bugs (arsenite of soda, stock solution) was used with the bordeaux in the first spraying at the rate of two quarts to 50 gallons. The water required was pumped by a windmill 20 rods distant. There were three rows 1436 feet long by 32 inches wide. They were treated with paris green once (July 19). The check rows died ten days earlier than the sprayed ones, owing chiefly to the ravages of flea beetles.

The items of expense were as follows:

312 lbs. copper sulphate @ 8c	$24 96
4 bu. lime @ 25c	1 00
20 lbs. sal. soda @ 2½c	50
5 lbs. white arsenic @ 15c	75
5 days labor for man @ $2	10 00
5 days labor for horse @ $1	5 00
Wear on sprayer	5 00
Total	$47 21

The yields of the test rows were as follows:

Average of two sprayed rows, 694 lbs.=131.5 bu. per acre.
Middle unsprayed row, 647 lbs.=122.6 bu. per acre.
Gain due to spraying, 8.9 bu. per acre.

The market price of potatoes at digging time being 75 cents per bushel the increase had a value of $6.67 per acre. After deducting the expense of spraying, $3.63 per acre, there remains *a net profit of* $3.04 *per acre.*

THE GENESEO EXPERIMENT.

This experiment, conducted by S. Fraser, Geneseo, N. Y., was in a young orchard in which 6-row strips of potatoes were planted between the rows of trees, the area devoted to potatoes being 17½ acres. The sprayer used was a two-horse, five-row Brown sprayer with two nozzles per row. The potatoes being in 6-row strips and the sprayer a 5-row machine it happened that the middle four rows of each strip were double-sprayed at each spraying. The whole field was sprayed six times and four acres of it a seventh time, the dates being: July 15-16, 23-25, August 7-9, 17-19-20-21, September 3-5, 16-18, 25-27. In the first spraying 6–4–50 bordeaux was used; in the others, 4–4–50. The water required was pumped by hand, most of it being obtained in the field. Arsenate of lead, for bugs, was used with the bordeaux in two sprayings. One 6-row strip was left for a check. The rows were 576 feet long by 39 inches wide. They were kept free of bugs by two applications of arsenate of lead. At no time was there much contrast between sprayed and unsprayed rows. There was no blight and but few flea beetles.

The expense account contained the following items:

845 lbs. copper sulphate @ 7½c	$63 37
6⅓ bbl. lime @ 90c	5 70
105 lbs. arsenate of lead @ 9c	9 45
205 hrs. labor for man @ 15c	30 75
205 hrs. labor for team @ 20c	41 00
Wear of sprayer	24 00
Total	$174 27

The test rows (which were of the variety Sir Walter Raleigh) received 7 double sprayings. The yields were as follows:

Average of 4 sprayed rows, 282 lbs.=109.3 bu. per acre.
Average of 2 check rows, 278 lbs.=107.8 bu. per acre.
Gain due to spraying, 1.5 bu. per acre.

At 50 cents per bushel, the market price of potatoes at digging time, the increase has a value of 75 cents. The expense of seven double sprayings being $13.37 per acre, there was *a loss of* $12.62 *per acre.*

THE ANDOVER EXPERIMENT.

Conducted by M. A. Crandall & Son, Andover, N. Y. Five acres of potatoes (in two lots) were sprayed five times with a one-horse, four-row "Watson" sprayer carrying one nozzle per row. The bordeaux used was of the 6–5–50 in the fifth. Water was obtained from a spring 40 rods distant from one lot and 80 rods from the other. In three sprayings one pound of paris green and two quarts of arsenite of soda stock solution were added to each 50 gallons of bordeaux to control bugs, which were very troublesome. Three rows 610 feet long by 32 inches wide were left for a check. These, also, were treated three times with paris green and, besides, the bugs were hand picked once. Early blight, late blight, tip burn, flea beetles and bugs were all factors in this experiment. Although sprayed and unsprayed rows seemed to have an equal chance so far as treatment for bugs is concerned the unsprayed rows were slightly more injured by bugs. The unsprayed rows died 10 to 14 days earlier than the sprayed ones.

The expense account contained the following items:

98 lbs. copper sulphate @ 8c	$7 84
95 lbs. lime @ 2c	1 90
22 lbs. sal soda @ 5c	1 10
4 lbs. paris green @ 35c	1 40
5½ lbs. white arsenic @ 20c	1 10
Labor for man and horse / Wear of sprayer } 40c per acre each application*	10 00
Total	$23 34

The test rows gave the following yields:

Average of two sprayed rows, 285 lbs.=127.1 bu. per acre.
Middle unsprayed row, 198 lbs.=88.3 bu. per acre.
Gain due to spraying, 38.8 bu. per acre.
There was no loss from rot.

At 50 cents per bushel 38.8 bushels have a value of $19.40. After deducting the expense of spraying, $4.67 per acre, there remains *a net profit of $14.73 per acre.*

* Mr Crandall did some spraying for neighbors at this price.

THE INTERLAKEN EXPERIMENT.

Conducted by F. C. and L. B. Bradley, Interlaken, N. Y., who sprayed 8¼ acres of potatoes (in two lots) four times — July 13, 24, August 7 and 23. The sprayer used was a two-horse, four-row "Watson" sprayer carrying one nozzle per row in the first and last sprayings and two nozzles per row in the second and third sprayings. The bordeaux used was of the 4–4–50 formula. In the first two sprayings paris green was added at the rate of one-half pound to 50 gallons. Water was obtained from a stream 25 rods distant. Three check rows were left in each lot. In the east lot the checks were 864 feet long by three feet wide; in the west lot, 726 feet long by three feet wide. The checks received paris green twice, July 13 and 24. At no time during the season was there any contrast in appearance between sprayed and unsprayed rows in either lot. There was no blight, no rot and no damage done by bugs. Flea beetles caused some damage and there was much tip burn.

The expense account contained the following items:

183 lbs. copper sulphate @ 8c	$14 64
204 lbs. lime	2 35
10 lbs. paris green @ 35c	3 50
48 hrs. labor for man @ 20c	9 60
40 hrs. labor for team @ 15c	6 00
Wear of sprayer	1 50
Total	$37 59

The test rows (variety, Carman No. 3) yielded as follows:

East Lot.— Two sprayed rows, 1354 lbs.=189.5 bu. per acre.
Middle unsprayed row, 559 lbs.=156.5 bu. per acre.
Gain due to spraying, 33 bu. per acre.
West Lot.— Two sprayed rows, 1086 lbs.=181 bu. per acre.
Middle unsprayed row, 456 lbs.=152 bu. per acre.
Gain due to spraying, 29 bu. per acre.
Average gain in two lots, 31 bu. per acre.

At 55 cents per bushel 31 bushels have a value of $17.05. After deducting the expense of spraying, $4.55 per acre, there remains *a net profit of* $12.50 *per acre.*

THE EAST SYRACUSE EXPERIMENT.

Conducted by M. W. Garrett, East Syracuse, N. Y. Four acres of potatoes were sprayed six times with a one-horse, four-row

"Iron Age" sprayer. In the first three sprayings one nozzle per row was used; in the last three sprayings, two nozzles per row. The dates of spraying were: July 5, 11, 17, 23, 31 and August 7. The bordeaux used was of the 6-6-50 formula. The water required was pumped by hand and hauled 100 rods. In all six sprayings one-half pound of paris green and one quart of arsenite of soda stock solution were added to each 50 gallons of bordeaux. Four check rows, 518 feet long by 3 feet wide were left unsprayed. These were treated four times with paris green. The check rows, being more severely attacked by early blight and flea beetles, died about two weeks earlier than the sprayed rows. There was also considerable tip burn which was partially controlled by the spraying. Late blight and rot were wholly absent and no damage was done by bugs.

The items of expense were as follows:

125 lbs. copper sulphate @ 10c	$12 50
125 lbs. lime	75
24 lbs. sal soda @ 1½c	36
6 lbs. white arsenic @ 15c	90
8 lbs. paris green @ 35c	2 80
18 hrs. labor for man @ 20c	3 60
18 hrs. labor for horse @ 10c	1 80
Wear of sprayer	5 00
Total	$27 71

The test rows (variety Green Mountain) yielded as follows:

Average of two sprayed rows, 432 lbs.=201.8 bu. per acre.
Average of two check rows, 342 lbs.=159.8 bu. per acre.
Increase in yield due to spraying, 42 bu. per acre.

The market price of potatoes at digging time being 75 cents per bushel the increase had a value of $31.50. After deducting the expense of spraying, $6.93 per acre, there remains *a net profit of $24.57 per acre.*

THE VERONA EXPERIMENT.

Conducted by F. G. Rathbun, Verona, N. Y., who sprayed ten acres twice with a one-horse, four-row "Spramotor" sprayer carrying three nozzles per row and applying about 75 gallons of bordeaux per acre. The dates of spraying were August 3-5 and 27-30. There were three check rows, 792 x 3 feet. July 13-15-16 the entire field was treated with paris green in water. In the first spraying

(August 3–5) poison was used with the bordeaux and the check rows also were poisoned on August 5. Late blight and rot were the enemies fought in this experiment. Late blight appeared about August 20 and attacking the unsprayed rows more severely than the sprayed ones caused them to die about two weeks earlier.

The expense account included the following items:

153 lbs. copper sulphate @ 8c	$12 24
139 lbs. lime @ 1c	1 39
28 lbs. sal soda @ 1c	28
7 lbs. white arsenic @ 8c	56
14 lbs. paris green @ 32c	4 48
40 hrs. labor for man @ 15c	6 00
38 hrs. labor for horse @ 10c	3 80
Wear on sprayer	11 30
Total	$40 05

The test rows (variety, Green Mountain) yielded as follows:

Average of two sprayed rows, 537 lbs.=164 bu. per acre.
Middle unsprayed row, 370 lbs.=113 bu. per acre.
Increase in yield due to spraying, 51 bu. per acre.

Although the weights taken show 34.5 bu. of rotten tubers per acre on the sprayed rows as against only 33.6 bu. on the unsprayed row, there can be no doubt that spraying lessened the loss from rot. On the unsprayed rows there were large numbers of tubers which were so much decayed that they could not be gathered for weighing, while on the sprayed rows there were only a few such tubers.

At 70 cents per bushel, the market price at digging time, 51 bushels of potatoes are worth $35.70. After subtracting the expense of spraying, $4 per acre, there remains *a net profit of* $31.70 *per acre.*

THE DENMARK EXPERIMENT.

Conducted by H. E. Cook, Denmark, Lewis County, N. Y. Six acres were sprayed 5 times with a two-horse, four-row "Aroostook" sprayer carrying two nozzles per row. The dates of spraying were July 20, August 16, 20, 27 and September 4. The bordeaux used was of the 5–5–50 formula with 1¼ pounds of paris green added in the first spraying. The checks consisted of two three-row strips 500 feet long the rows being three feet apart. The check rows were treated with paris green twice — July 20 and 25.

The expense account contained the following items:

250 lbs. copper sulphate @ 8½c	$21 25
300 lbs. lime	1 25
13½ lbs. paris green @ 34c	4 57
50 hrs. labor, man and team @ 30c	15 00
Wear on sprayer	5 00
Total	$47 07

One test was in the variety Carman No. 3, the other in the variety Green Mountain. The yields were as follows:

Test No. 1.—Carman No. 3.—Average of two sprayed rows, 500 lbs.=223.3 bu. per acre.

Middle unsprayed row, 498 lbs.=222.4 bu. per acre.

Increase in yield due to spraying, 0.9 bu. per acre.

Test No. 2. Green Mountain.—Average of two sprayed rows, 570 lbs.=254.6 bu. per acre.

Middle unsprayed row, 347 lbs.=155 bu. per acre.

Increase in yield due to spraying, 99.6 bu. per acre.

Average gain in the two tests, 50.2 bu. per acre.

At 50 cents per bushel the market value of this gain was $25.10. The expense of spraying being only $7.84 per acre *the net profit from the operation was* $17.26 *per acre.*

Why the results were so widely different in the two tests is not known. The difference in variety does not account for it satisfactorily. Mr. Cook reports that in the test on Green Mountain the unsprayed rows were markedly inferior to the sprayed ones being more injured by late blight and tip burn. There was no early blight, no rot and no injury from bugs.

THE OGDENSBURG EXPERIMENT.

Conducted by Andrew Tuck, Ogdensburg, N. Y. Four acres of potatoes (variety, Rural New Yorker No. 2) were sprayed four times with a one-horse, four-row "Aspinwall" sprayer carrying one nozzle per row. The dates of spraying were August 7, 16, 26 and September 9. The bordeaux used was of the 5–5–50 formula, the water required being pumped by hand from a well within a few rods of the field. There were three check rows, 600 feet long by 33 inches wide. On July 31 the entire field was treated with paris green in water. Subsequently, paris green was used with the bordeaux in all four sprayings while on the check rows it was applied only twice—August 7 and 16. Throughout the season the

field was practically free from all kinds of insect and fungus pests excepting bugs, but these did no more damage to the unsprayed rows than to the sprayed ones.

The items of expense were as follows:

70 lbs. copper sulphate @ 8c	$5 60
70 lbs. lime @ 1c	70
24 lbs. paris green @ 30c	7 20
30 hrs. labor for man @ 15c	4 50
24 hrs. labor for horse @ 10c	2 40
Wear of sprayer	3 00
Utensils (barrels, pail, etc.)	1 50
Total	$24 90

The yields on the test rows were as follows:

Average of two sprayed rows, 461 lbs.=202.8 bu. per acre.

Middle unsprayed row, 431 lbs.=189.6 bu. per acre.

Gain due to spraying, 13.2 bu. per acre.

In Ogdensburg, the market price of potatoes at digging time was 80 cents per bushel. At this price the increase would have a value of $10.56 per acre. After deducting the expense of spraying, $6.22 per acre, there remains *a net profit of $4.34 per acre.*

THE CHATEAUGAY EXPERIMENT.

Conducted by Oliver Smith & Son, Chateaugay, N. Y. Seven acres were sprayed four times with a one-horse, four-row "Iron Age" sprayer carrying one nozzle per row. The dates of spraying were July 16, August 1, 22 and September 2. The bordeaux (6–6–50 formula) was prepared with water pumped by horse power from a well at one side of the field. In the first two sprayings arsenite of soda, stock solution, was used with the bordeaux at the rate of two quarts to 50 gallons. There were two checks of three rows each, both in the variety Uncle Sam. These received two applications of paris green — July 17 and August 8. The sprayed rows outlived the unsprayed ones by nearly a month. Early blight, late blight and flea beetles were all factors in this experiment. The longer life of the sprayed rows was plainly due to their protection against these pests. No rot was found at digging time.

The expense account contained the following items:

175 lbs. copper sulphate @ 6½c	$11 38
1 bbl. lime	1 15
32 lbs. sal soda @ 3c	96
8 lbs. white arsenic @ 8c	64
15½ hrs. labor for man @ 20c	3 10
15½ hrs. labor for horse @ 10c	1 55
Wear of sprayer	10 00
Total	$28 78

In one case the test rows were 1050 ft. x 37 in.; in the other 934 ft. x 37 in. The yields were as follows:

Test No. 1.—Two sprayed rows, 1526 lbs.=171 bu. per acre.
Middle unsprayed rows, 554 lbs.=124.2 bu. per acre.
Gain from spraying, 46.8 bu. per acre.
Test No. 2.—Two sprayed rows, 1250 lbs.=157.5 bu. per acre.
Middle unsprayed row, 477 lbs.=120.2 bu. per acre.
Gain from spraying, 37.3 bu. per acre.
Average gain in the two tests, 42 bu. per acre.

At 50 cents per bushel the gain has a market value of $21. After subtracting the expense of spraying, $4.11 per acre, there remains *a net profit of* $16.89 *per acre.*

THE PLATTSBURGH EXPERIMENT.

Conducted by Pardy Bros., Plattsburgh, N. Y. Eleven acres (variety unknown) were sprayed with bordeaux mixture four times — July 16, 29, August 2 and about August 16. Before spraying was begun the entire field was treated (July 12) with arsenite of soda solution in lime water to control bugs. Further treatment for bugs consisted in the use of arsenite of soda with the bordeaux in three sprayings. The spraying was done with a two-horse, six-row "Aroostook" sprayer carrying one nozzle per row. The bordeaux was of the 6–6–50 formula. The water was pumped by hand and hauled about 100 rods. There were three check rows, 354 feet long by 32 inches wide. These received three applications of poison (July 16, 31 and August 9); also the bugs were removed from them by hand once (August 2). The unsprayed rows died about a month earlier than the sprayed ones. The cause of this is not entirely clear. Unfortunately, the writers were unable to examine the experiment during August and September. The unsprayed rows were more injured by early blight and also by bugs

although so far as bugs are concerned the experiment seems to have been a fair one. There was no rot.

The expense account contained the following items:

312 lbs. copper sulphate @ 7c	$21 84
2 bbl. lime @ $1	2 00
25 lbs. sal soda @ 2c	50
30 lbs. white arsenic @ 11c	3 30
4½ days labor for man @ $1.50	6 75
4⅓ days labor for man and horse @ $3.75	16 25
Wear of sprayer	7 00
Total	$57 64

The test rows gave the following yields:

Average of two sprayed rows, 373 lbs.=286.8 bu. per acre.
Middle unsprayed row, 197 lbs.=151.5 bu. per acre.
Gain due to spraying, 135.3 bu. per acre.

The market price of potatoes being 65 cents per bushel 135.3 bushels would have a value of $87.94. Deducting the expense of spraying, $5.24, there is left *a net profit of* $82.70 *per acre.*

THE GREENWICH EXPERIMENT.

Conducted by P. C. Billings, Greenwich, N. Y. Ten acres of potatoes were sprayed all over three times and six acres were given a fourth application. The sprayer was a two-horse, six-row "New Model Aroostook" carrying one nozzle per row. In the first spraying 4–4–50 bordeaux was used; in the later ones, 6–6–50 bordeaux. The water used was dipped from a tank filled by a windmill. It had to be hauled about 75 rods. Paris green was used with the bordeaux in three sprayings and the entire field was treated twice besides with paris green in lime water (one pound to 50 gallons). The three check rows, 665 x 3 feet, were treated four times with paris green — June 29, July 1, 13 and 23. The dates of spraying with bordeaux were June 29, July 10, 23 and August 14. The contrast between sprayed and unsprayed rows was not great, but toward the close of the season it was plain that the unsprayed plants had lost more of their lower leaves. However, both sprayed and unsprayed plants carried some green foliage through to frost. They suffered but little from insect or fungus enemies of any kind.

The items of expense were as follows:

204 lbs. copper sulphate @ 10c	$20 40
204 lbs. lime @ 1⅓c	2 72
26 lbs. paris green @ 35c	9 10
20 hrs. labor for man @ 20c	4 00
20 hrs. labor for team @ 30c	6 00
Wear of sprayer	5 00
Total	$47 22

Where the test rows were located, the potatoes were of the Twentieth Century variety. The yields were as follows:

Average of two sprayed rows, 486 lbs.=176.8 bu. per acre.
Middle unsprayed row, 426 lbs.=155 bu. per acre.
Increase in yield due to spraying, 21.8 bu. per acre.

Notwithstanding the freedom of the plants from insects and blight, spraying proved profitable. The market price of potatoes at the time of digging the test rows was 50 cents per bushel. Accordingly, the value of the increased yield was $10.90. Subtracting the expense of spraying, $5.24 per acre for four sprayings, we have left *a net profit of* $5.66 *per acre.*

THE BREWSTER EXPERIMENT.

Conducted by E. F. Hayt, Brewster, N. Y., who sprayed 6 acres twice (July 17 and 26) using a one-horse, home-made, four-row sprayer pumped by hand and carrying one nozzle per row. In the first spraying, 4–4–50 bordeaux was used; in the second, 6–4–50. Arsenite of soda stock solution was used with the bordeaux in both sprayings. In addition, hills here and there were dusted with paris green as needed. There were three check rows, 371 x 3 ft. These were treated with paris green four times — July 3, 13, 7 and 30. The season being a very dry one there was very little blight. Flea beetles injured both sprayed and unsprayed plants considerably and their ravages were not checked in the least by spraying. There was absolutely no contrast between sprayed and unsprayed rows.

The expense account contained the following items:

60 lbs. copper sulphate @ 10½c	$6 30
48 lbs. lime @ 1½c	72
24 lbs. sal soda @ 1½c	36
6 lbs. white arsenic @ 12½c	75
12 hrs. labor for man @ 15c	1 80
12 hrs. labor for boy @ 10c	1 20
12 hrs. labor for horse @ 15c	1 80
Wear of sprayer	1 00
Total	$13.93

The test rows (Twentieth Century) yielded as follows:

Average of two sprayed rows, 203 lbs.=122.3 bu. per acre.
Middle unsprayed row, 225 lbs.=135.5 bu. per acre.
Loss, 13.2 bu. per acre.

Believing that there had been no late blight Mr. Hayt was surprised to find many rotten tubers — 33.7 bu. per acre on the sprayed rows and 39.1 bu. on the unsprayed. Probably, there was a light attack of late blight late in the season. Perhaps a couple of additional sprayings would have prevented this and made the spraying profitable. Why the unsprayed rows outyielded the sprayed ones is not known. It can scarcely have been due to the spraying. With potatoes at 80 cents per bushel and the expense of spraying $2.32 per acre *the apparent loss was* $12.88 *per acre.*

THE JAMESPORT EXPERIMENT.

Conducted by Henry A. Hallock, Jamesport, Long Island, seventeen acres of potatoes (in two lots) were sprayed five times. The sprayer used was a one-horse, four-row "Hudson" sprayer carrying two nozzles per row. The dates of spraying were July 1, 13, 25, 31 and August 7. The water used in preparing the bordeaux was pumped with a gasoline engine and hauled from 10 to 80 rods. In the first two sprayings paris green was used with the bordeaux. The four check rows in each lot were treated with paris green twice — July 1 and 13. The unsprayed rows died two weeks earlier than the sprayed ones owing to the ravages of flea beetles which had been much lessened by spraying. There was no blight or rot.

The expense account contained the following items:

340 lbs. copper sulphate @ 8c	$27 20
2 bbl. lime @ $1.85	3 70
68 lbs. paris green @ 28c	19 04
50 hrs. labor for man @ 20c	10 00
50 hrs. labor for horse @ 20c	10 00
Wear of sprayer	5 00
Total	$74 94

In both lots the test rows were of the variety Green Mountain. In Lot No. 1 the rows were 718 x 3 ft.; in Lot No. 2, 692 x 3 ft. The yields were as follows:

Lot No. 1.—Two sprayed rows, 1650 lbs.=278 bu. per acre.
One of middle two check rows, 703 lbs.=236.9 bu. per acre.
Increase in yield due to spraying, 41.1 bu. per acre.
Lot No. 2.—Two sprayed rows, 956 lbs.=167.1 bu. per acre.
One of middle check rows, 453 lbs.=158.4 bu. per acre.
Increase in yield due to spraying, 8.7 bu. per acre.

Combining the results obtained in the two tests we find an average gain of 24.9 bu. per acre. The market price of potatoes in Riverhead being 72½ cents per bushel[10] at digging time the gain has a value of $18.05. After deducting the expense of spraying, $4.41 per acre, there remains *a net profit of* $13.64 *per acre.*

THE SAGAPONACK EXPERIMENT.

Conducted by Paul Roesel, Sagaponack, Long Island, who sprayed 34 acres of potatoes (variety, Green Mountain) ten times. The sprayer was a two-horse, five-row "Brown" sprayer carrying one nozzle per row. The bordeaux used in this experiment was soda bordeaux (6 lbs. copper sulphate, 7½ lbs. sal soda and 50 gals. water). There were two four-row checks. The sprayed portion of the field received two applications of paris green with bordeaux (3 lbs. to 50 gals.) in the first two sprayings and the checks, also, were treated with paris green twice (June 27 and

[10] Seventy cents per bushel when the test rows in Lot No. 1 were dug and 75 cents when those in Lot No. 2 were dug, making the average price 72½ cents per bushel.

July 5). Bugs were kept well under control. There was little if any blight and no rot in this experiment, but there was a severe attacks of flea beetles which were considerably checked by the spraying.

The expense account included the following items:

1710 lbs. copper sulphate @ 8¼c	$141 08
2240 lbs. sal soda @ 1¼c	28 00
295 lbs. paris green @ 31c	91 45
93½ hrs. labor for man @ 20c	18 70
93½ hrs. labor for team @ 45c	42 08
Wear of sprayer	23 00
Total	$344 31

In Test No. 1 the rows were 960 x 3 ft.; in Test No. 2, 891 x 3 ft. The yields were as follows:

Test No. 1.— Two sprayed rows, 2490 lbs.=313.7 bu. per acre.
Average of two check rows, 1010 lbs.=254.5 bu. per acre.
Increase in yield due to spraying, 59.2 bu. per acre.
Test No. 2.— Two sprayed rows, 2000 lbs.=271.5 bu. per acre.
Average of two check rows, 717.5 lbs.=194.8 bu. per acre.
Increase in yield due to spraying, 76.7 bu. per acre.
Average increase in the two tests, 67.9 bu. per acre.
At 70 cents per bushel[11] 67.9 bushels have a value of $47.53.

After deducting the expense of spraying, $10.13 per acre, there remains *a net profit of* $37.40 *per acre.*

SUMMARY OF BUSINESS EXPERIMENTS IN 1907.

The principal features of the fourteen farmers' business experiments are shown in the following table:

[11] Between the time of digging Test No. 1 and Test No. 2 the market price of potatoes rose from 60 to 80 cents per bushel. Hence, the average price of 70 cents is used.

TABLE XVI.— SHOWING RESULTS OF BUSINESS EXPERIMENTS IN 1907.

EXPERIMENT.	Area sprayed.	Number of times sprayed.	Increase in yield per acre.	Total cost of spraying per acre.	Cost per acre for each spraying.	Net profit per acre.
	Acres.		*Bu.*			
Batavia..........	13	4	8.9	$3 63	$0.91	$3 04
Genseo...........	17.5	6–7	1.5	13 37	†1 15	—12 62
Andover..........	5	5	38.8	4 67	93	14 73
Interlaken........	8.25	4	31.	4 55	1 14	12 50
East Syracuse....	4	6	42	6 93	1 15	24 57
Verona...........	10	2	51	4 00	2 00	31 70
Denmark..........	6	5	50.2	7 84	1 57	17 26
Ogdensburgh......	4	4	13.2	6 22	1 55	4 34
Chateaugay.......	7	4	42	4 11	1 03	16 89
Plattsburgh......	11	4	135.3	5 24	1 31	82 70
Greenwich........	10	3–4	21.8	5 24	1 31	5 66
Brewster.........	6	2	13.2	2 32	1 16	—12 88
Jamesport........	17	5	24.9	4 41	88	13 64
Sagaponack.......	34	10	67.9	10 13	1 01	37 40

SUMMARY OF BUSINESS EXPERIMENTS, 1903–1907.

The following table shows the results of the farmers' business experiments for five years, 1903 to 1907 inclusive:

TABLE XVII.— SHOWING RESULTS OF BUSINESS EXPERIMENTS, 1903–1907.

YEAR.	Number of experiments.	Total area sprayed.	Average increase in yield per acre.	Average total cost of spraying per acre.	Average cost per acre for each spraying.	Average net profit per acre.
		A.	*Bu.*			
1903............	6	61.2	57	$4 98	$1 07	$23 47
1904............	14	180	62.2	4 98	93	24 86
1905............	13	160.7	46.5	4 25	98	20 04
1906............	15	225.6	42.6	5 18	9 85	13 89
1907............	14	152.75	36.8	5 90	1 18	17 07

Average increase in yield, for five years, 49 bu. per acre.
Average net profit, for five years, $19.86 per acre.

† Seven sprayings cost $13.37, but it should be observed (see p. 255) that each so-called application was in reality, 1⅙ applications. Hence, the cost of a single application was $1.15.

TABLE XVIII.— SHOWING RESULTS OF VOLUNTEER EXPERIMENTS IN 1907.

Experiment.	Location.	Name.	Area sprayed.	Times sprayed.	Yield per acre.* Sprayed.		Yield per acre.* Not sprayed.		Gain per acre due to spraying.		Cost per acre each spraying.	Price of potatoes.	Kind of sprayer.
			A.		Bu.	lbs.	Bu.	lbs.	Bu.	lbs.		Cts.	
1	West Rush	T E. Martin	18	17	304	—	216	—	88	—	$0 84	50	Home made, 1-horse, 6-row.
2	Bridgehampton	F. C. Howell	16	7	199	31	113	10	86	21	90	65	"Perfection," 1-horse, 6-row.
3	West Rush	D. S. Norris	5.5	6	175	54	105	32	70	22	62	50	Home-made, 1-horse, 4-row.
4	Elbridge	J. D. Rhoades	12	3	276	—	207	—	69	—	......	50	"Standard," 2-horse, 6-row.
5	Fulton	V. W. Shattuck	6.5	6	183	55	131	5	52	50	1 56	50–60	1-horse, 4-row.
6	Cutchogue	R. W. Sterling	9.5	5	175	30	132	—	43	30	......	75–80	"Hudson," 1-horse, 4-row.
7	N. Brookfield	J. B. Nash	3 rows	4	262	2	218	37	43	25	......	50	Hand sprayer.
8	Elba	C. W. Driggs	6	3	144	16	101	16	43	20	88	50	"Aroostook," 2-horse, 4-row.
9	Sterling Sta.	A. E. Curtis	18	5–7†	220	45	178	25	42	—	......	55	Home-made, 1-horse, 4-row.
10	Falconer	N. Cheney	9	5	116 163	29 30	106 99	35 2	37	11‡	94	75	Home-made, 1-horse, 4-row
11	Andover	J. M. Greene	14	4	220	48	187	12	33	36	93	50	"Watson," 2-horse, 4-row.
12	Dewittville	G. A. Kirkland	5.5	5	108	56	79	3	29	53	1 34	75	"Spramotor," 1-horse, 4-row.
13	Pittsford	F. Ernst, Jr.	15	3	199	40	177	29	22	11	......	50	"Aroostook," 2-horse, 6-row.
14	Cassville	P. S. Doolittle	14	3	198	54	179	—	19	54	93	50	"Aspinwall," 1-horse, 4-row.
15	Lisbon	S. Miller	1.5	4	151	57	136	7	15	50	1 05	75	Home-made, 1-horse, 2-row.
16	Syracuse	G. G. Hitchings	18	4–5	74	25	58	41	15	44	67	75	Niagara Gas, 2-horse, 2-row.
17	Naples	C. M. Crouch	12	3	168	35	153	15	15	20	......	50	Hurst's Wheelbarrow, 4-row.
18	Avoca	J. Fox	6	4	108	3	101	15	6	48	51	50	"Watson," 2-horse, 4-row.
19	Canandaigua	S. L. Van Voorhis	7.5	3	200	—	196	—	4	—	......	50	Home-made, 2-horse, 6-row.
20	Riverhead	W. L. McDermott	25	4	187	—	183	—	4	—	......	65	"Iron Age," 1-horse, 4-row.
21	Water Mill	C. B. Foster	17	8	254	16	250	49	3	27	1 06	70	"Shangle," 2-horse, 5-row.
22	W. Henrietta	C. M. Lyday	12	5	170	24	170	24	0	0	1 02	55	"Perfection," 2-horse, 6-row.
23	Hunt	A. Reese	14	3	105	36	105	36	0	0	1 33	50	"Brown," 2-horse, 5-row.
									Loss.				
24	Constableville	C. H. Zimmer	2.5	1	244	12	259	52	15	40	.....	50–55	4-gallon, compressed air.

* Marketable tubers only † Six acres sprayed 7 times, the remainder 5 times. The test rows were in the portion sprayed 7 times. ‡The average of 2 experiments.

VOLUNTEER EXPERIMENTS.

The details of 24 tests made by growers in 1907 and reported to the Station are shown in Table XVIII, page 269.

SUMMARY OF VOLUNTEER EXPERIMENTS, 1904–1907.

The following table shows the results obtained in the volunteer experiments during the past four years:

TABLE XIX.—SHOWING RESULTS OF VOLUNTEER EXPERIMENTS, 1904–1907.

YEAR.	Number of experiments.	Total area sprayed.	Average gain per acre due to spraying.		Average market price per bushel of potatoes at digging time.
		A.	*Bu.*	*lbs.*	*Cts.*
1904	41	364	58	28	43.5
1905	50	407	59	32	57.0
1906	62	598	53	6	44.5
1907	24	264	30	28	58.0

Average gain for 4 years (177 experiments) 50⅓ bu. per acre.

POTATO TROUBLES IN NEW YORK IN 1907.

Owing to dry weather in midsummer there was very little late blight (Phytophthora) anywhere in the State. In some localities there was a light attack late in the season resulting in some loss from rot. Flea beetles were unusually abundant and because of the dry weather their attacks were very injurious to the plants causing the leaves to turn brown and dry up. There was also much tip burn due to dry weather alone. The chief troubles were flea beetles and dry weather. In many cases these troubles were mistaken for blight.

DIRECTIONS FOR SPRAYING.

The observations made in 1907 tend to confirm us in the opinion that potatoes should be sprayed five or six times during the season regardless of weather conditions. It is a mistake to discontinue spraying on account of dry weather. We see no reason for altering the recommendations for spraying given in Bulletin No. 290, page 320.

REPORT

OF THE

Chemical Department.

L. L. Van Slyke, *Chemist.*
A. W. Bosworth, *Associate Chemist.*
E. L. Baker, *Associate Chemist.*
A. W. Clark, *Assistant Chemist.*
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M. P. Sweeney, *Assistant Chemist.*
J. T. Cusick, *Assistant Chemist.*
Otto McCreary, *Assistant Chemist.*

TABLE OF CONTENTS.

Methods of paying for milk at cheese factories.

REPORT OF CHEMICAL DEPARTMENT.

METHODS OF PAYING FOR MILK AT CHEESE FACTORIES.*

L. L. VAN SLYKE.

SUMMARY.

1. Introduction. The subject has been under discussion for about twenty years. The discovery of the Babcock test made practicable the introduction of the milk-fat basis. This method has been displaced in many cases, the chief and fundamental cause being the hostile attitude of the producers of milk poor in fat.

2. The relation of fat in milk to cheese yield. Milk rich in fat usually contains less casein in proportion to fat than does milk poorer in fat. On this account, a pound of fat in rich milk usually corresponds to less cheese than does a pound of fat in poorer milk.

3. The relation of milk constituents to composition of cheese. The composition of cheese-solids (cheese minus water) depends practically upon the relation of fat and casein in milk. In cheese made from milk rich in fat, the proportion of fat in the cheese-solids is higher than in the case of cheese made from milk less rich in fat.

4. The relation of the composition of cheese to its quality. Other things being equal, cheese containing a high proportion of fat in relation to cheese-solids is superior in quality and market value to cheese containing a smaller proportion of fat in its solids. This is supported by the results of the Wisconsin cheese-scoring contest of 1908, and by work done at the experiment stations of Wisconsin, Iowa, Minnesota and New York. This view has been supported and advocated by Dr. Robertson and others, of Canada, by Dr. Babcock and Prof. Farrington, of the Wisconsin experi-

* A reprint of Bulletin No. 308.

ment station, and by many others who are recognized as authorities on such questions. While a pound of fat in rich milk is equivalent to less cheese than in the case of milk poorer in fat, the cheese made from richer milk is enough better in quality to make up for the slight difference in yield.

5. Paying for milk on basis of weight. Under this system, each patron receives the same amount of money for 100 pounds of milk. While this method possesses the advantage of convenience and simplicity, it is open to the following objections: (a) It is unfair to the producer of richer milk. (b) It discourages progress in the production of better milk. (c) It encourages the watering and skimming of milk. (d) All things considered, it is the poorest possible method of paying for milk for cheese-making.

6. Paying for milk on basis of milk-fat. On this basis, each patron receives the same amount of money for each pound of fat in the milk delivered by him. This method is objected to by producers of milk that is low in fat mainly on the ground that the percentage of fat in milk is not generally a strictly accurate measure of the amount of cheese made from 100 pounds of milk. Objections other than this, so far as they are worthy of consideration, have been easily met. This system possesses the following advantages: (a) The amount of fat in the milk offers a practicable and just basis for ascertaining the cheese-producing value of milk when we consider both quality and quantity. (b) This method eliminates all temptation to skim or water the milk. (c) It encourages improvement in the character of milk production, which results in economy of production and increased profit. (d) It tends to raise the production and care of milk to a higher plane of intelligence.

7. Paying for milk on basis of cheese yield and relative value of cheese-solids. This method was proposed by Dr. Babcock. It considers the yield of cheese from different milks and the composition of the cheese-solids, allowing for fat a value of 6.6 as compared with a value of 1.0 for the cheese-solids other than fat. Values are worked out which give figures, to be used in making dividends, corresponding to varying percentages of fat in milk. The chief objection urged against this method is that it requires, in addition to the fat test, a determination of the specific gravity by the Quevenne lactometer. It possesses the general advantages offered by the simple milk-fat basis.

8. Paying for milk on the " fat plus two " basis. By this method the percentage of fat is increased by two and the results used the

same as in making dividends on the fat basis. This system is an attempt to approximate the yield of cheese as a basis for making dividends. It allows payment for two pounds of casein, in addition to fat, in the case of all milks. The following objections are made to this method: (a) It considers yield of cheese alone and not quality. (b) It does not recognize any casein in milk above 2 per ct., though milks richer in fat are known to contain, in general, more casein than milks containing less fat. (c) This method is in the interest of the producer of poor milk at the expense of the producer of richer milk. (d) It offers a premium on watering and skimming milk. (e) It is in opposition to the teachings of Robertson, Babcock and many other recognized authorities, so far as it works in favor of poor milk at the expense of richer milk.

9. Paying for milk on basis of fat and casein. Under this system the percentages of fat and casein in each patron's milk are added and the figures thus obtained are used in distributing dividends. This method has the advantages of being an accurate measure of cheese yield and of removing temptation to water milk. It has the following disadvantages: (a) When carried out in the most complete manner, it involves making a casein test in addition to a fat test, requiring extra time, labor and cost. (b) It does not recognize any difference in the quality or value of cheese made from milks containing different percentages of fat. (c) It offers a temptation to skim milk. (d) It places the value of casein on a par with that of milk-fat, contrary to the teachings of Babcock, and encourages the production of milk with higher percentages of casein relative to fat. (e) From results obtained in applying this method to data obtained in case of a representative New York cheese-factory, the changes made in the distribution of dividends would be insufficient to justify the extra expense involved in making a casein test, in comparison with the milk-fat basis.

10. Modification of fat and casein basis. If casein were assigned one-fourth the value of milk-fat, in harmony with Babcock's relative value-plan for cheese yield and solids, and if this value, added to that of milk-fat, were used in making dividends, we should get results essentially like those given by the milk-fat basis. Under such circumstances, the cost of making a casein test would be practically thrown away.

11. Payment on basis of milk-fat and calculated casein. The percentage of casein in milk can be approximately calculated when the percentage of milk-fat is known. Casein thus estimated could

be used with fat in making dividends without the cost of a casein test. Such a method considers only quantity and not quality of cheese but, apart from this fundamental weakness, possesses the following advantages: (a) It is preferable to the fat-and-casein method, in that no extra expense is required for making a casein test. (b) It is more fair than the " fat plus two " method, since richer milk would be credited with more casein than poorer milk. (c) All temptation to water or skim milk would be wholly eliminated. (d) No additional labor is involved in making dividends, as compared with the milk-fat basis.

12. Suggestions to New York dairymen. (a) The exclusive use of the milk-fat basis is advised. (b) The distribution of dividends on the exclusive basis of weight of milk should be abandoned. (c) When it is impossible to introduce the simple milk-fat basis, some modification may be used such as described above in paragraphs 7, 11, or 8, preference being in the order given. (d) The introduction of a casein test, in view of the absence of facts proving its practicability, is not advisable at present.

INTRODUCTION.

Methods of paying for milk at cheese-factories have been under more or less constant discussion for about twenty years. Shortly before the year 1890, some question was raised as to the fairness of paying for milk at cheese-factories by weight. Two factors worked against the realization of any practical results coming from such discussion: (1) Lack of knowledge regarding the relation of milk-constituents to yield and quality of cheese, and (2) the need of a practicable method for determining any of the cheese-making constituents of milk. In 1890 Dr. Babcock furnished his method of determining fat in milk, and then the discussion soon centered about the use of fat in milk as a basis for paying for milk used in cheese-making. The application of the test in the case of butter-making was at once understood and utilized; but, in conection with cheese-making, it was known that two constituents are concerned, fat and casein, and the question was therefore more complicated than in the case of butter-making where only fat is concerned. During the years 1891 to 1895, a large amount of investigation was carried on, especially at this Station, which resulted in giving us such a comprehensive and systematic knowledge of the relations of milk-constituents to cheese as had not been possible previously. In general, it was shown that, while the amount of fat in milk is

not an absolute guide in respect to the yield of cheese from milks containing different amounts of fat, it is a very much more accurate index than the mere weight of milk; and that, while, in case of milks containing higher percentages of fat, the yield of cheese is usually less for a pound of milk-fat than in the case of milk containing lower percentages of fat, the cheese made from the richer milk is of more excellent quality and has a higher commercial value.

The fat basis began to be introduced into actual cheese-factory work about 1892, and its use spread quite rapidly during the next few years. This method was at first received with considerable enthusiasm. After a few years a reaction gradually took place and the system was abandoned in many factories, which went back to the old method of paying for milk by weight only. There are several reasons why the fat basis in paying for milk for cheese-making has experienced its up and downs, like every other reform movement, and we will notice some of the most prominent of these.

(1) Wherever the fat basis replaced the weight-of-milk method, the change affected the dividends of different patrons in different ways. Those furnishing milk containing percentages of fat above the average received more money for their milk, while those furnishing milk containing percentages of fat under the average found their dividends reduced. Therefore, the owners of cows giving milk low in fat were bitterly disappointed and exercised their ingenuity in discovering reasons why the fat basis was objectionable and unfair. *The attitude of the producer of poor milk is, of course, the fundamental reason why the fat basis has been abandoned in some cases where it had been introduced.* The other objections raised were subordinate to this one, though some of them had, perhaps, some real basis, though only temporary and exceptional.

(2) The reliability of the Babcock test was attacked and the accuracy of its results called into question. The points of objection raised on this ground were: (a) That the Babcock method of testing milk for fat is unreliable under all circumstances; (b) that, while the method, when properly handled, is accurate, cheese-makers are careless or inefficient in operating the test, and their results are therefore inaccurate; (c) that the glassware was not always accurately graduated and consequently gave incorrect results; (d) that cheese-makers deliberately gave some patrons higher results than those indicated by the test. The general charge of inaccuracy of the test itself was, of course, prompted by ignorance or malice or both. There was probably once some justification for the charge

of carelessness and inefficiency against operators of the Babcock test; for it was undoubtedly true to some extent that cheese-makers attempted to employ the method who had not been properly instructed in its use nor acquired the requisite accuracy of manipulation. There was at one time a strong disposition to over-emphasize the extreme simplicity of the Babcock test and to lose sight of the fact that even so simple a method requires careful attention to every detail and that certain precautions must be strictly observed. It was also true that some manufacturers became careless and put on the market glassware that was inaccurate. This difficulty has been effectively overcome in most of the prominent dairy states by an official testing of all graduated glassware used in the Babcock test, before it is placed on sale. The charge that, in some cases, cheese-makers have wrongly manipulated the test in the interests of favored patrons, has some foundation. Such an abuse constitutes no real basis of objection to the method of paying for milk on the fat basis, because no method can be devised which cannot be similarly abused. Such a practice is indulged in at great risk, because it is not difficult of detection. Moreover, the possibility of such abuse is effectively and easily overcome by having a committee of patrons supervise all testing of milk.

(3) Many cheese-makers object to the added work involved, even when paid for it. An unwilling cheese-maker can easily influence patrons against the method.

(4) Another cause for the discarding of the fat basis in many cases was the confusion introduced by proposing some modification of the method in the interest of the producer of poorer milk, a point which we will consider more fully later.

The subject has been discussed in many of its aspects in two bulletins of this Station, No. 68 (March, 1894) and No. 110 (October, 1896). These bulletins have been out of print for some years. New phases of the question have arisen, which have awakened inquiries among those interested in cheese-making. It has, therefore, seemed desirable that the whole subject should be presented anew.

SOME FUNDAMENTAL CONSIDERATIONS.

Before discussing in detail the various methods which have been proposed for the purpose of paying for milk at cheese-factories, we will present some fundamental considerations, which form an

essential basis in enabling us to pass judgment upon the methods in question.

(1) The relation of fat in milk to cheese yield.
(2) The relation of milk-constituents to composition of cheese.
(3) The relation of the composition of cheese to its quality.

THE RELATION OF FAT IN MILK TO CHEESE YIELD.

Much study has been given, especially at this Station, to the quantitative relations existing between the percentage of fat in milk and the yield of cheese, or the amount of cheese corresponding to one pound of fat in milk. The relation is a very simple one to calculate and is found by dividing the number of pounds of cheese made from 100 pounds of milk by the number representing the percentage of fat in milk. For example, the yield of cheese from 100 pounds of milk containing 3 per ct. of fat is 8.31 pounds; the ratio of milk-fat to cheese yield is, therefore, 8.31÷3, which equals 2.77; that is, in this case, one pound of fat in milk is equivalent to 2.77 pounds of cheese. In the case of milk containing 4 per ct. of fat and producing 10.60 pounds of cheese for 100 pounds of milk, each pound of fat in milk is equivalent to 2.65 pounds of cheese.

The study of this relation was first undertaken at this Station to ascertain whether a pound of fat in all normal milks is equivalent to the same amount of cheese. The bearing of this point upon the use of fat in milk as a basis of paying for milk at cheese-factories is obvious. If a pound of fat in milk were always equivalent to the same amount of cheese, then no question could arise as to the strict accuracy of a milk-fat basis in making dividends. If the amount of cheese made for a pound of fat in milk varies, then the fat could not be regarded as a strictly accurate measure of cheese yield, and other points than yield would need to be considered, such as the quality of the cheese, in measuring the value of milk for cheese-making.

Our work has shown that the yield of cheese is chiefly dependent upon two constituents of milk, casein as well as fat. It is obvious that if fat and casein were always present in milk in the same relative proportions, then the yield of cheese would always be in the same uniform ratio to milk-fat. But we have found that the ratio of fat and casein in milk varies considerably and, for this reason, the ratio of milk-fat to yield of cheese must also vary.

It is a matter of practical interest and importance to know what the extent of such variations may be.

Taking milk as it averages, we find the following variation of relation between fat and cheese yield in normal milks containing different amounts of fat. The cheese yield is based on a uniform percentage of water in the cheese, 37 per ct.

TABLE I.—RATIO OF FAT TO CHEESE YIELD IN NORMAL MILK.

Fat in milk.	Casein in milk.	Amount of cheese made from 100 pounds of milk.	Amount of cheese made for each pound of fat in milk.
Per ct.	*Per ct.*	*Lbs.*	*Lbs.*
3.00	2.10	8.30	2.77
3.25	2.20	8.88	2.73
3.50	2.30	9.45	2.70
3.75	2.40	10.03	2.67
4.00	2.50	10.60	2.65
4.25	2.60	11.17	2.63
4.50	2.70	11.74	2.61
4.75	2.80	12.31	2.59
5.00	2.90	12.90	2.58

Casein, as we have shown, does not increase as rapidly as fat does in milk, and, therefore, milk richer in fat usually contains less casein in proportion to fat than does milk less rich in fat. In harmony with this condition and as a result of it, the amount of cheese made for a pound of milk-fat decreases as the percentage of fat in milk increases. This is clearly shown in the preceding table.

An interesting fact shown in this table is that the rate of decrease of the ratio of fat to cheese yield is less rapid as the percentage of fat in milk increases. Thus, in the case of milks containing 3 and 3.25 per ct. of fat, the decrease of cheese yield in relation to fat is from 2.77 to 2.73, a difference of 0.04 pound; between 3.25 and 3.50, and also between 3.50 and 3.75, the decrease is 0.03; for each 0.25 per ct. of increase of milk-fat; from 3.75 to 4.75 per ct., the decrease in the ratio is only 0.02; and between 4.75 and 5.00 per ct., the decrease is only 0.01. This is explained by the well-known fact that, in the case of milk rich in fat, a smaller proportion of the fat is lost in cheese-making than in the case of milk poorer in fat.

THE RELATION OF MILK CONSTITUENTS TO COMPOSITION OF CHEESE.

The composition of the solids of cheese (cheese minus water) depends practically upon the relation of fat and casein in milk.

Milk rich in fat, as compared with milk poor in fat, usually produces cheese containing more fat in proportion to other constituents. The composition of cheese depends primarily upon the composition of the milk used, provided the process of cheese-making is performed in a normal manner, so as to avoid excessive loss of fat or casein. In this connection we shall discuss the relation of composition of milk to composition of cheese (a) in case of normal milk, (b) in case of skimmed milk, and (c) in case of milk containing added cream.

Composition of cheese from normal milk.— The composition of green cheese, in case of normal factory milk, as made in New York State, shows the following range of variations and general average as determined by extended investigations carried on by this Station.

TABLE II.— COMPOSITION OF GREEN CHEESE.

	Lowest.	Highest.	Average.
	Per ct.	*Per ct.*	*Per ct.*
Water	32.69	43.89	36.84
Total solids	56.11	67.31	63.16
Fat	30.00	36.79	33.83
Proteins	20.80	26.11	23.72
Salts, etc. (represented in ash)	3.12	7.02	5.61
Percentage of solids in form of fat	50.39	56.83	53.56
Ratio of fat to proteins	1 : 0.79	1 : 0.63	1 : 0.70

We can illustrate differences in composition of cheese made from normal milks differing in composition by taking cheese made from the milk of different breeds of cows. For this purpose, we will use the composition of milk as found in case of four different breeds.

TABLE III.— COMPARSION OF CHEESE MADE FROM MILK OF DIFFERENT BREEDS.

BREED.	Solids in cheese.	Fat in cheese.	Proteins in cheese.	Percentage of total solids in form of fat.	Ratio of fat to proteins.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Fat : Proteins.*
Holstein Friesian	63.00	34.1	23.6	54.3	1 : 0.69
Ayrshire	63.00	34.5	23.3	54.8	1 : 0.67
Guernsey	63.00	37.0	20.8	58.7	1 : 0.56
Jersey	63.00	37.5	20.4	60.0	1 : 0.54

The difference in composition is very clearly seen especially if we notice the percentage of the cheese-solids present in the form of fat and the ratio of fat to proteins as shown in the last two columns.

The following table extends the illustration systematically to ordinary milks containing different percentages of fat. We may regard these as representing milks of different herds.

TABLE IV.— COMPOSITION OF CHEESE MADE FROM MILKS OF DIFFERENT COMPOSITION.

Fat in milk.	Cheese solids.	Fat in cheese.	Proteins in cheese.	Percentage of total solids in form of fat.	Ratio of fat to proteins.
Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Fat : Proteins*
3.00	63.00	33.7	24.1	53.5	1 : 0.72
3.25	"	34.1	23.7	54.0	1 : 0.70
3.50	"	34.5	23.3	54.6	1 : 0.68
3.75	"	34.8	23.0	55.2	1 : 0.66
4.50	"	35.1	22.7	55.7	1 : 0.65
4.25	"	35.4	22.4	56.2	1 : 0.63
4.50	"	35.7	22.1	56.7	1 : 0.62

These tables strikingly indicate that, as milk increases in percentage of fat, the cheese made from such milk increases in percentage of fat and decreases in percentage of proteins. The composition of the cheese-solids follows the composition of the milk as shown in the relation of fat and proteins.

Composition of cheese made from skimmed milk.— The removal of fat from milk reduces the amount of fat in relation to casein, because, in skimming milk, only a relatively small amount of casein is removed with the fat. The remaining skim-milk is therefore richer in casein relative to fat, the ratio increasing with the amount of fat removed. The effect of skimming milk upon its composition of cheese is illustrated in the two following tables. The data are based upon (1) normal milk containing 4 per ct. of fat; (2) removal of fat alone without other constituents; (3) a uniform percentage of casein in skim-milk, and (4) a uniform percentage (37) of water in cheese. While the data represent theoretical conditions, the results are not far from the truth in practical application and they serve satisfactorily to illustrate the point we desire to impress.

TABLE V.—EFFECT OF SKIMMING MILK OF COMPOSITION OF MILK AND YIELD OF CHEESE.

	Fat removed from 100 pounds of milk.	Fat left in skimmed milk.	Casein in skimmed milk.	Ratio of fat to casein in milk.	Cheese.
	Lbs.	*Lbs.*	*Lbs.*	*Fat : Casein.*	*Lbs.*
1.	0.00	4.00*	2.50	1 : 0.63	10.60
2.	0.50	3.50	2.50	1 : 0.71	9.79
3.	1.00	3.00	2.50	1 : 0.83	8.98
4.	2.00	2.00	2.50	1 : 1.25	7.37
5.	3.00	1.00	2.50	1 : 2.50	5.71
6.	3.90	0.10†	2.50	1 :25.00	4.33

TABLE VI.—EFFECT OF SKIMMING MILK ON COMPOSITION OF CHEESE.

	Fat in cheese.	Proteins in cheese.	Cheese-solids in form of fat.	Ratio of fat to proteins in cheese.
	Per ct.	*Per ct.*	*Per ct.*	*Fat: Proteins.*
1.	35.1	22.7	55.7	1 : 0.65
2.	33.3	24.5	53.0	1 : 0.74
3.	31.1	26.7	49.4	1 : 0.86
4.	25.2	32.6	40.0	1 : 1.30
5.	16.1	41.7	25.5	1 : 2.60
6.	2.3	55.5	3.7	1 : 24.00

In making cheese from skim-milk, the yields given are lower than those obtained in commercial work, because here we allow for only 37 per ct. of water, while commercial skim-milk cheese never contains so little moisture but usually from 40 to 55 per ct., the moisture held in cheese increasing as the percentage of fat in skim-milk decreases. In comparing the results in this table with those in the table on page 282, in which the composition is shown of cheese made from milk low and high in fat. we see that the difference there is the same in character as that brought about by partially skimming whole milk. For example, by skimming from 100 pounds of Jersey milk, containing 5.78 per ct. of fat, 1.25 pounds of fat, thus reducing the fat to 4.53 per ct. the resulting milk and cheese will then be essentially the same in composition, in relation

* Normal milk. † Separatior skm-milk.

to cheese-solids, as the normal Holstein-Friesian milk as shown by the following table:

TABLE VII.—COMPARISON OF NORMAL MILK AND PARTIALLY SKIMMED RICH MILK.

	Fat.	Casein.	Ratio of fat to casein.
	Per ct.	*Per ct.*	*Fat: Casein.*
Holstein-Friesian milk....................	3.26	2.20	1 : 0.67
Jersey milk (normal)......................	5.78	3.03	1 : 0.52
Jersey milk (partially skimmed)............	4.53	3.03	1 : 0.67

Of course, the same result could be accomplished by adding skim-milk to milk rich in fat.

There is another way of comparing milks which, like these, are poor and rich in fat. Thus, how much fat would it be necessary to add to the Holstein-Friesian milk to have it make cheese like that made from Jersey milk? Calculation shows that nearly one pound of fat would need to be added to 100 pounds of the Holstein milk, which is thus shown:

Fat in milk.	Fat added.	Percentage of fat in enriched milk.	Percentage of casein in milk.	Ratio of fat to casein Fat: Casein.
3.26.	+ 0.94	= 4.20	2.20	1 : 0.52

It can, therefore, be seen that the differences existing between rich and poor milk are, so far as relates to the composition of the cheese made from them, such as can be adjusted by removing fat from the rich milk or adding skim-milk to it, or by adding fat to skim-milk. *The difference in milk poor in fat which makes the fat go farther in making cheese is a difference which may be characterized, in a general way, as a skim-milk difference, because it depends upon a relatively high proportion of casein.*

Composition of cheese made from milk containing added cream.—Addition of cream to normal milk affects the cheese made from such milk in a way directly opposite to that produced by skimming; that is, it increases the proportion of fat in cheese in relation to proteins. A single illustration will suffice. We give the composi-

tion of cheese made from normal milk containing 4 per ct. of fat and also from the same milk after its fat content has been increased to 6 per ct. by the addition of cream.

TABLE VIII.—COMPOSITION OF CHEESE MADE FROM MILK CONTAINING ADDED CREAM.

	Fat in milk.	Amount of cheese for 100 lbs of milk.	Fat in cheese.	Proteins in cheese.	Cheese-solids in form of fat.	Ratio of fat to proteins.
	Per ct.	*Lbs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Fat: Proteins.*
Normal milk..........	4.00	10.60	35.1	22.7	55.7	1 : 0.65
Enriched milk........	6.00	13.80	40.4	17.4	64.0	1 : 0.43

THE RELATION OF THE COMPOSITION OF CHEESE TO ITS QUALITY.

In the preceding discussion, it has been demonstrated that cheese made from milk rich in fat contains relatively and actually more fat and less proteins than cheese made from milk poor in fat. Two such cheeses, made with equal skill, the milk being uniform in every way except in composition, show a marked difference in commercial quality; and the one having the larger percentage of fat would be declared to be superior in quality. This has been demonstrated in practical ways by the experiment stations of Wisconsin, Iowa, Minnesota and New York; and their work, the first to be done along these lines, has been supplemented and confirmed by the work of others. It has been found generally true that cheese made from milk containing added cream is superior in flavor and texture to that made from ordinary normal milk; and that made from normal milk is superior in flavor, texture, body and keeping quality to cheese made from skim-milk.

Variation in quality in cheddar cheese follows more or less closely the relation of fat to proteins in cheese; the larger the proportion of fat, the better, in general, the quality of cheese and the higher the market value. This fact is, of course, associated with, and dependent upon, the function that milk-fat performs in cheese, that of imparting smoothness of feeling, mellowness of body, richness and delicacy of taste and palatability. Bearing on this particular point the late Henry E. Alvord makes the following statement:[1] "Other things being equal, a cheese containing a large percentage of fat is better, because, first, of its finer flavor and taste; second,

[1] *U. S. Dept. Agr. Year Book* 1895: 471.

of its better consistency; third, of its improved aroma; fourth, of its increased digestibility; fifth, of its more perfectly answering the requirements of a complete food or balanced ration." In this connection, it is interesting to learn that in Germany the custom of selling cheese according to the percentage of fat contained in it is rapidly coming into use.

While the view expressed above is very generally held and is based upon experimental work, there have been no extensive commercial opportunities for demonstrating the matter in a systematic way. But some valuable facts bearing on this point in a most direct and practical form have just been developed in the four Wisconsin cheese-scoring contests[2] held during April, May, June and July, 1908. The facts are all the more interesting because they are merely incidental to the general purpose of these contests. The method of conducting these competitive tests in Wisconsin cannot be too highly recommended to other states, especially because very full details are given, unusual under such circumstances, making the work of peculiar value in enabling one to study relations existing between the composition of cheese and its commercial value. In each of these monthly scorings, it is significant that the cheese scoring highest contained the largest amount of fat relative to proteins, while the cheese scoring lowest in every case contained the lowest amount of fat relative to proteins, as shown by the following data:

TABLE IX.—RELATION OF FAT AND PROTEIN IN CHEESES OF HIGH AND LOW SCORES.

	CHEESE SCORING HIGHEST.			CHEESE SCORING LOWEST.		
	Fat.	Proteins.	Ratio of fat to proteins.	Fat.	Proteins.	Ratio of fat to proteins.
	Per ct.	*Per ct.*	*Fat: proteins.*	*Per ct.*	*Per ct.*	*Fat: proteins.*
April	36.	27.	1 : 0.75	32.	29.2	1 : 0.91
May	35.25	27.4	1 : 0.78	35.	29.2	1 : 0.83
June	35.	27.5	1 : 0.79	34.5	29.8	1 : 0.86
July	35.	29.46	1 : 0.84	34.3	29.3	1 : 0.86

The most striking difference is shown by the April results, the least by those of July. In studying all the available data, the only apparent cause that accounts for these differences is the difference

[2] *N. Y. Prod. Rev. and Amer. Crmy.* 26: 182, 348, 504. 652. 1908.

in composition. In the case of some of the cheeses that were scored second and third below the highest, as compared with others that were scored second and third from the lowest, the general relation of quality and composition was shown but not equally in every case. While these results do not in themselves absolutely prove the relation between composition and commercial quality, their special value is that they confirm, in a different way, the results of other work.

It cannot fail to be of value in the discussion of this subject to present the views of some of those who have been generally regarded as authorities in relation to the commercial as well as to the scientific aspects of cheese-making. For this purpose we have chosen to give the views (1) of Dr. Robertson, so long Canada's most efficient leader in the progress of all branches of dairying and especially of cheese-making, and (2) of Dr. Babcock, who has been properly regarded as America's leading student of dairying in its scientific relations and who has given special attention to the question under discussion.

In the report of the New York Dairymen's Association for 1891, we find the following statements in an address given by Dr. Robertson: "In every case there was a gradual reduction in the quantity of cheese when there was a less quantity of butter-fat in milk. . . . However, this is true also, that the increased yield of cheese is not in direct proportion to the increased percentage of butter-fat; that is, milk containing 3 per ct. of butter-fat will yield a certain quantity of cheese, but if you take milk having one-third more fat (4 per ct.) it will not yield one-third more cheese. *At the same time, such milk is worth one-third more for cheese-making, and thereby hangs a tale.* You see, if it does not yield so much cheese, it makes a *quality* of cheese so much better that the market value of the cheese from 100 pounds of milk is a third greater than the market value of the cheese in the other case" (pp. 198–9). "Every two-tenths of a pound of butter-fat will improve the quality of the cheese one-eighth cent per pound, as near as I can find out. Thus, you have a difference of about five-eighths of a cent per pound between cheese made from 3 per ct. and 4 per ct. milk" (p. 201).

Dr. Babcock approaches the question from quite another point of view (report of New York Dairymen's Association for 1892, pp. 150, 153, etc.). After showing that fat is the constituent controlling the value of milk, cream and butter, he says: "It is evident

that the market price of milk, of cream and of butter depends chiefly upon the price of butter-fat, and that other constituents have so little influence that they can practically be neglected.

"There is one other important dairy product to be considered, and that is cheese. Does the same principle hold with this? I believe it does; for on no other basis can I reconcile market prices all over the world."

He then goes on to show by actual market quotations that cheese varies in price according to its richness in fat, all the way from 11 cents per pound for whole-milk, fancy cheese down to 1 to 2½ cents a pound for full-skim cheese. Anticipating some objections raised to the method of reasoning as applied to the fat basis as a method of paying for milk at cheese-factories, he continues: "I cannot leave this subject without referring to some of the objections made to its use in cheese-factories. It is urged that because casein and fat are intimately mixed together in cheese, they bring the same price per pound when sold, and so should be given the same price in calculating the value of milk that is to be used for this purpose. If this is true, the water which comprises a larger portion of cheese than the casein should be treated in the same way, and worthless constitutents in any product should have the same value as the mixture in which they occur. It is absurd, on the face of it, as it gives entirely different values to the same constituent according to the product considered. It makes the casein, water and fat worth each about one cent per pound in milk, the same constituent worth 30 cents per pound in butter and anywhere from 1 to 11 cents per pound in cheese, according to the proportions in which they are mixed. Whereas, the relative value plan gives consistent values in all.

"Again, it is said that the life-sustaining power of a pound of casein is about the same as a pound of fat, and that they should therefore have about the same value; but it must be borne in mind that the nutritive value and the market value of foods have no relation to each other. You can buy nutrients in corn meal cheaper than you can in wheat flour. Maple sugar costs you two or three times as much as beet sugar, although the two have identically the same effect. All of these things are controlled by the universal law of supply and demand, and have nothing to do with their relative food value.

"When any article has a high value for any special purpose, that fixes the price which must be paid for it for all other purposes.

You cannot afford the use of rosewood or mahogany for fuel, not because they have less heat-producing power than maple or birch, but because they command a higher price for piano cases or other articles of furniture. The general public esteems butter-fat more highly than casein and are willing to pay a much higher price for it. It is folly to stand in your own light and argue that this is inconsistent."

These arguments of Dr. Babcock are based on general economic truths which hold good to-day as fully as when they were stated by him. They are facts which sould be kept in mind when considering the relation of composition of cheese to commercial quality or market value. In the 12th annual report of the Wisconsin experiment station (p. 115), Dr. Babcock also says:

"It is a well-established fact that rich milk gives a better quality of cheese which commands a higher price than that from poor milk."

We add also the following quotation from an address given before the Wisconsin cheesemakers' convention at Milwaukee, in 1907, by Prof. E. H. Farrington, dairy husbandman at the Wisconsin experiment station: "It will be seen that the richer the milk, the better the price per pound of cheese made from it. I am occasionally asked if 100 pounds of milk testing 6 per ct. of fat will make twice as much cheese as 100 pounds of milk testing 3 per ct. of fat. The answer to this question is briefly that the cheese made from the richer milk is of much better quality and worth a higher price per pound than that made from the thinner milk, and this will help balance any difference in yield. The influence of the richness of milk on the quality of cheese is something that should not be lost sight of in considering the question of paying for milk at a cheese-factory by the Babcock test."

DIFFERENT METHODS OF PAYING FOR MILK AT CHEESE-FACTORIES.

In the history of the cheese-making industry, we can distinguish in the order of their appearance, five methods which have been proposed for the purpose of paying for milk at cheese-factories:

(1) Weight of milk.

(2) Amount of fat in milk.

(3) Relative values of fat and other cheese-solids based on yield and composition of cheese.

(4) Modification of fat basis to include part of the milk-casein.
(5) Amount of fat and casein in milk.

We will now consider each of these methods as to comparative merits and defects.

PAYING FOR MILK ON BASIS OF WEIGHT.

Under this system each patron receives the same amount of money for each 100 pounds of milk delivered at the factory. This method possesses the advantage of simplicity and economy of time, involving no additional work. Among the disadvantages of this method are the following:

(1) It assumes, as a fundamental basis of its fairness, that all kinds of normal milk have the same cheese-producing value; that, from 100 pounds of any milk, we make the same amount of cheese. This assumption has been abundantly proved not to be true, since the yield of cheese from 100 pounds of milk may vary all the way from 8 to 13 pounds or more. The method is, therefore, unfair to the producers of milk containing higher percentages of fat.

(2) This system discourages the production of milk of higher percentage in fat. When weight alone is considered in making payment, more money can be received by increasing the amount of milk produced, without regard to its composition; and it is thus found more profitable to produce milk as low in fat as legal requirements permit.

(3) This system breeds criminality, because it encourages the addition of water, removal of cream and all similar forms of dishonesty. Some dairymen have regarded the direct addition of water to milk as the most economical way of increasing milk production for cheese-making purposes, but the experience is not usually attended with most economical results for any length of time.

However much difference of opinion there may exist in regard to the efficiency of different methods of paying for milk for cheese-making, all who are in position to give a reliable judgment in the matter agree on this one point, viz., among the various methods proposed, this one is farthest from doing justice to all producers of milk.

PAYING FOR MILK ON BASIS OF FAT.

When milk is paid for on the basis of its fat content, each patron receives the same amount of money for each pound of fat in the milk delivered. For example, the patron whose milk contains 3 per ct. of fat receives payment for 3 pounds of fat for each 100 pounds of milk delivered by him; while the patron whose milk contains 4 per ct. of fat receives payment for 4 pounds of fat for each 100 pounds of milk furnished by him. The second patron receives one-third more per 100 pounds of milk than the first one, while, under the weight-of-milk method, each would receive an equal sum. This can be illustrated as follows:

For the sake of simplicity, we will compare the milks furnished by two patrons, one milk containing 3, and the other 4 per ct. of fat. We will assume that the cheese sells for 10 cents a pound. We will make the comparison on the basis of 100 pounds of milk, allowing that the cheese yield from 100 pounds of milk containing 3 per ct. fat is 8.30 pounds, and from milk containing 4 per ct. of fat, 10.60 pounds, a total of 18.90 pounds, bringing 189 cents. By the weight-of-milk method, this sum is divided equally between the two patrons, because each furnishes the same amount of milk. Hence, each receives 94.5 cents for the cheese made from his milk. On this basis the one furnishing milk containing 3 per ct. of fat receives 11.4 cents a pound for each pound of cheese made from milk furnished by him; while the other receives 8.9 cents for each pound of cheese made from his milk.

Dividends based on the percentages of fat in milk are made as follows: One patron furnishes 3 pounds of fat and the other, 4. There are, all told, 7 pounds of fat, the cheese corresponding to which sells for 189 cents. Therefore, each pound of fat is credited with 27 cents; one patron receives 81 (27×3) cents and the other, 108 (27×4) cents. In this case the one furnishing the poorer milk receives 9.76 cents a pound for the cheese made from his milk, and the other, 10.19 cents. The existing difference, 0.4 cent a pound, is generally held to represent an actual difference in the quality and value of the cheese. These results can be very well shown in the following tabulated form:

TABLE X.—COMPARISON OF DIVIDENDS MADE ON WEIGHT-OF-MILK AND ON MILK-FAT BASIS.

WEIGHT-OF-MILK METHOD.					MILK-FAT BASIS.		
Fat in 100 pounds of milk.	Cheese made from 100 pounds of milk.	Dividend.	Money received for each pound of cheese.	Money received for each pound of milk-fat.	Dividend.	Money received for each pound of cheese.	Money received for each pound of milk-fat.
Lbs.	*Lbs.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
3	8.30	94.5	11.4	31.5	81	9.76	27
4	10.60	94.5	8.9	23.6	108	10.19	27

Of the various objections deserving any attention, which have not already been noticed, the following are the chief ones urged against this method:

(1) The percentage of fat in milk is not generally an accurate measure of the amount of cheese made from 100 pounds of milk. A pound of fat in milk containing 3 per ct. of fat represents more cheese than does a pound of fat in milk containing 4 per ct. of fat; in the former case, the cheese yield is 2.77 pounds for one pound of fat in milk, while in the latter it is 2.65 pounds. On this account, the milk containing least fat does not receive pay for all the cheese it makes.

(2) The cost of making the test is often raised as an objection. In actual practice, the difficulty has been satisfactorily overcome. The usual custom is to pay the cheese-maker at the rate of 20 to 25 cents a month for each patron.

The principal reasons given for favoring the fat basis are the following:

(1) This method recognizes the fundamental truth that normal milks varying in percentage of fat possess different values for cheese-making.

(2) The amount of fat in milk offers a practicable and just basis for determining the cheese-producing value of milk, when we consider both quality and quantity (p. 286).

(3) All temptation to adulterate milk by watering or skimming is absolutely removed, since a man receives pay for the number of pounds of fat that he furnishes and not merely for the number of pounds of liquid he carries to the factory. No other method now in use so completely eliminates the temptation to adulterate milk.

(4) This method promotes improvement in the character of milk production. This is not merely a theoretical statement, *but has been proved to be true in practice.* It offers an inducement to each dairyman to improve the composition of his milk.

(5) Improvement in the character of dairy animals and in the consequent yield and composition of milk means economy of production and increase of profit. *Cheese-solids in rich milk can be produced at less cost than in poor milk.*

(6) This method awakens interest in the subject of milk production, stimulates a desire for further knowledge and tends to place the production and care of milk on a higher plane of intelligence.

PAYING FOR MILK ON THE BASIS OF CHEESE YIELDS AND RELATIVE VALUE OF CHEESE-SOLIDS.

In the twelfth annual report of the Wisconsin experiment station (pp. 114-119), Dr. Babcock has worked out a system of payment by which the yield of cheese and composition are both taken into consideration. The principles embodied in this method have not received the general attention deserved. He says: "*It is not sufficient for a system to give the true yield from each patron's milk, for this makes skim-milk cheese equally valuable with that from the richest milk. The perfect system of making dividends in cheese-factories must include, not only the amount, but also the relative values of fat and the other cheese-producing solids; with such a system each patron will receive his just proportion whether he brings skim-milk, watered milk or cream.*" His proposed method gives to milk-fat a value of 6.6, as compared with a value of 1.0 for the cheese-solids not fat. A table is worked out, based on yield of cheese and relative value of cheese-solids for milks containing different percentages of fat from 2 to 6. Values are given which can be used directly in the same manner as the percentages of fat are used in case of the fat basis. The only additional labor required is to apply the lactometer to each milk and take the reading.

He says, further: "*This modification would give to each patron the same amount of money which he would obtain if his milk were manufactured by itself.* In this respect it differs widely from those modifications of the relative-value plan *which aim to make dividends in proportion to the pounds of cheese which each milk will produce, leaving out entirely the quality of the cheese.*" The following illustration shows the application of this method:

One patron furnishes milk showing by test 3 per ct. of fat and a lactometer (Quevenne) reading of 28; another, milk with 4 per ct. of fat and a lactometer reading of 34. Turning to the table referred to, it is found that milks corresponding to these percentages of fat and lactometer readings have relative values for cheese-making represented by the numbers 4.10 and 5.43. To find the dividend of each, we divide the amount of money (189 cents) received, by the sum (9.53) of these two numbers, which gives 19.83. This number multiplied by 4.10 and 5.43 gives the respective dividends of the two patrons.

TABLE XI.—DIVIDEND ON BASIS OF CHEESE YIELD AND SOLIDS.

Fat in 100 pounds of milk	Cheese made from 100 pounds of milk	Dividend	Money received for each pound of cheese	Money received for each pound of milk-fat
Lbs.	*Lbs.*	*Cents*	*Cents*	*Cents*
3	8.30	81.3	9.80	27.10
4	10.60	107.7	10.16	26.92

By comparing these results with those given by the simple fat basis and other methods, we see that the values are much closer to the results of the fat basis than those given by any other method.

Application of principle to fat and casein.—This same principle could be readily applied when we know the percentages of fat and of casein in milk. We might be even more liberal and instead of allowing only one-sixth for casein, allow as much as one-fourth. In this case, the dividends would be based on the fat plus one-fourth of the casein in each case. We will consider this more in detail later.

MODIFICATION OF FAT BASIS KNOWN AS THE "FAT-PLUS-TWO" METHOD.

By this method the percentage of fat in milk is increased by 2 and the results used the same as in making dividends on the fat basis. The method originated in Canada. The first suggestion was made about 1893, when at one of the cheese-factories the plan was adopted of adding 1 to the fat in making dividends, because it was noticed that this method more closely approximated the cheese yield than the use of fat alone. This method was made a subject of study at the Ontario Agricultural College and was modified by adding 2 to the fat in making dividends.

The dividends are made in the following manner under this method, using the illustration already given (p. 291) for milks containing 3 and 4 per ct. of fat. The receipts from sale of cheese are 189 cents. Instead of one patron receiving three-sevenths and the other four-sevenths of this amount, one receives five-elevenths and the other six-elevenths, as shown thus:

$$
\begin{array}{l}
3+2=5 \ (5-11) \\
4+2=6 \ (6-11) \\
\hline
7+4=11
\end{array}
$$

The results, compared with those of the fat basis, are as follows for this particular illustration:

TABLE XII.—COMPARISON OF DIVIDENDS ON FAT BASIS AND "FAT + 2" BASIS.

Fat in 100 pounds of milk	Cheese made from 100 pounds of milk	Fat Basis method			Fat-plus-Two method		
		Dividend	Money received for each pound of cheese	Money received for each pound of milk-fat	Dividend	Money received for each pound of cheese	Money received for each pound of milk-fat
Lbs.	*Lbs.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
3	8.30	81	9.76	27	86	10.36	28.7
4	10.60	108	10.19	27	103	9.72	25.7

This method is based on an attempt to approximate yield of cheese as a basis to use in paying for milk. It is supposed that the addition of 2 to the percentage of fat makes allowance for the casein of the milk, and, therefore, that milks which are low in fat will get such a proportion of casein as will balance the difference existing between milk poor in fat and milk rich in fat in respect to yield of cheese per pound of fat; and that, therefore, taking the casein into consideration along with the fat will give us a more accurate relation in regard to yield of cheese and percentage of fat in milk. This ought to be true and is true to a certain degree. So far as we do take casein into consideration, we get just that much nearer to the average of cheese yield, speaking of *yield alone* and not considering *quality*.

The objections which have been brought against this method are the following:

(1) It does not recognize any casein in milk above 2 per ct.; it would be a fair measure of yield of cheese if all milks contained 2 per ct. of casein, no more and no less. This is, of course, not in accordance with the actual facts. The additional amount of casein above 2 per ct., which is usually found in richer milks, is wholly ignored by this method. For example, under this method, milk containing 4 per ct. of fat would, after adding 2, be given a value of 6, whereas it should be given a value of 6.4 or 6.5 or more on the basis of its usual casein content.

(2) This method is, therefore, in the interest of milk low in fat. It gives undue advantage to poorer milk, and, to the same extent, works against the producer of richer milk. It has been generally held that too much encouragement cannot be given to farmers to produce milk of richer composition. In the illustration given above, one fails to see the justice of a method which gives to the producer of poorer milk 10.36 cents a pound for his cheese and to the producer of richer milk only 9.72 cents a pound for cheese that is better, if each milk is made into cheese by itself.

(3) This method offers a premium on watering milk, because the percentage of fat in milk (high or low) is credited with only 2 per ct. of casein; and, hence, the lower the percentage of fat, the larger will be the relative amount of casein and the greater the price received for each pound of fat. For example, a patron furnishing milk with 4 per ct. of fat could add, say, 33 pounds of water to 100 pounds of milk, thus reducing the percentage of fat to 3. He would then have the benefit of the added factor for 133 pounds of milk instead of 100 pounds. He would thereby increase his dividend from 103 to 108 cents.

(4) This method also offers a premium on skimming as well as watering milk. This can best be made clear by illustration. A patron who furnishes milk containing 4 per ct. of fat skims it so as to make it contain 3 per ct. and then adds enough water to make the weight of milk 100 pounds again. The cheese made from 100 pounds of such milk would be about 8.9 pounds. The milk of the other patron, who furnishes 100 pounds of normal milk containing 3 pounds of fat, makes 8.3 pounds of cheese, a total of 17.2 pounds for the 200 pounds of mixed milk. This, we assume, sells for 172 cents and is evenly divided between the two patrons, because each furnishes milk containing 3 per ct. of fat. Each, therefore, re-

ceives 86 cents. If the patron who produces milk with 4 per ct. of fat takes the normal milk to the factory, he receives on the "fat-plus-two" basis 103 cents, as we have already seen. If he skims his milk as described above, he receives 86 cents, or 17 cents less; but he has, as an offset to this, one pound of milk-fat which he can sell for 25 cents to 30 cents. Therefore, he is the gainer by all that he can get for his pound of milk-fat over 17 cents.

(5) This method, in opposition to the teachings of Robertson, Babcock, Farrington and many others, wholly ignores the fact that composition and quality vary with fat in milk and that cheese made from richer milk is of higher value.

While these objections hold good, still the fat-plus-two" method is unquestionably a great advance over the old weight-of-milk method. The most unfortunate feature about his method is the confusion which its introduction has caused among dairymen. Instead of regarding it as a modification of the fat basis, dairymen have, in many cases, thought that the whole principle of paying for milk by any other method than the weight-of-milk system was under suspicion. Dairymen do not yet understand the details of different methods clearly enough to discriminate, and, when they are told that the fat basis is unreliable and inaccurate, they most naturally lose confidence in all methods based on the fat-test and go back to the weight-of-milk system. Those who produce poor milk take advantage of such an opportunity to upset the entire system based on the fat-test. Thus, the whole situation has been needlessly confused, rather than benefited, for the average cheese-factory patron.

PAYING FOR MILK ON BASIS OF FAT AND CASEIN.

By this method the percentages of fat and casein in each patron's milk are added and the figures thus obtained are used in apportioning dividends as in the fat basis. The usual form in which this method has been proposed gives to the fat and casein equal values as cheese-producing constituents. This form will be first considered and can be illustrated as follows:

We will make use of the figures already employed in illustrating the other methods. One patron furnishes milk containing 3 per ct. of fat and 2.1 per ct. of casein; the other, milk with 4 per ct. of fat and 2.5 per ct. of casein. Each furnishes 100 pounds of milk; the total amount of cheese made is 18.9 pounds, realizing 189 cents. We add together the amounts of fat and casein in the two milks, ob-

taining 11.6 as the total number of pounds of fat and casein in the 200 pounds of milk. The total amount of money received for the cheese is divided by the total amount of casein and fat, which gives us 16.3 cents as the value of each pound of mixed fat and casein in milk. The dividend of the patron furnishing the poorer milk is 16.3×5.1, which equals 83 cents; the dividend of the other is 16.3×6.5, which equals 106 cents. In this case, each receives the same price for the cheese, 10 cents a pound, but not the same for milk-fat; the poorer milk receives 27.7 cents a pound for its fat; the richer milk, 26.5 cents. Below are given in tabulated form the results of this and the other methods already considered:

TABLE XIII.—COMPARISON OF RESULTS OF DIFFERENT METHODS OF PAYING FOR MILK.

Fat in milk	Casein in milk	Cheese	Dividend by fat and casein	Dividend by fat method	Dividend by "fat+2" method
Per ct.	*Per ct.*	*Lbs.*	*Cts.*	*Cts.*	*Cts*
3	2.1	8.30	83	81	86
4	2.5	10.60	106	108	103

The fat-and-casein method has the following advantages:

(1) It is an accurate measure of the yield of cheese in the case of all kinds of milk, when the losses of milk constituents are not excessive.

(2) The temptation to adulterate by watering is entirely removed.

The following disadvantages suggest themselves:

(1) Assuming that a test for casein gives results as accurate as the Babcock test for fat in the hands of ordinary cheese-makers, it is objected that the test involves extra labor on the part of the cheese-maker, for which he cannot well afford the time. The same objection is often made against the Babcock test, and it would, of course, be much more forceful in regard to a casein-test.

(2) An extra test involves additional cost, even in case a cheese-maker could find time to make both fat and casein tests. If a cheese-maker were paid on the basis of what is received for making fat-tests, it would amount to $50 or $60 a season for most cheese-factories. To this must be added cost of materials and breakage of glassware, which might be conservatively placed at $10 to $15. There would thus be a total outlay on the part of the patrons

amounting to $60 to $75 for the season in having the casein-test made.

(3) The fat-and-casein method does not recognize any difference in the value of cheese made from milk high and low in percentage of fat. It places the market value of casein on an absolute level with milk-fat, while Dr. Babcock gives milk-fat in cheese a value 6.6 times that of casein (p. 293).

(4) The use of the fat-and-casein method offers a temptation to remove fat from milk or to add skim-milk, in case of milk to be used for cheese-making. To illustrate, casein in skim-milk has a market value for the dairyman not to exceed 2 or 3 cents a pound, while milk-fat is worth about 30 cents a pound. In good cheese, casein and fat together bring about 18 cents a pound. If casein is paid for on a par with fat, then by adding skim-milk to normal milk, one can increase the price of his skim-milk casein about nine times. The same would be true if fat were removed from milk and sold as butter or cream. In whatever manner one increases the ratio of casein to fat in milk, he increases the dividend value of casein in cheese-making, when fat and casein are treated as of equal value in making dividends.

(5) The fat-and-casein method requires more time in calculating dividends.

(6) Some have expressed the fear that, under this system, the increased value of casein would lead dairymen to breed cows for milk high in casein, and that this would result in a poorer quality of cheese and general consequent danger to the cheese industry. In fact, the use of cows giving milk with a high casein content has been specifically emphasized by some as a desirable end to work for and it is urged that such an aim would be realized by the recognition of casein in cheese-making as of equal value with fat. Assuming that the percentage of casein in milk could be notably increased in an economical manner, what would be the result? By referring to pages 281–284, it can readily be seen that the process would be nothing more or less than a system of adding skim-milk to normal milk, thereby increasing the amount of casein in milk relative to fat. This fact is probably not fully appreciated by those who are advocating the process. We have probably reached the limits of safety, in more than one sense, in many strains of Holsteins and Ayrshires, as regards the high relation of casein to fat. We do not need to spend time and energy to breed cows for milk in the direction of skim-milk for cheese-making. Some progressive dairymen are,

happily, still so old-fashioned in their ideas as to advocate the opposite process, viz., increasing the yield of fat in milk without paying any attention to its skim-milk constituent, casein. This is simply raising the old question that used to be discussed so much 20 years and more ago regarding the " butter cow " and the " cheese cow." Thus, in the 1892 report of the Vermont experiment station (pp. 122, 123) this whole question is ably discussed, the article closing as follows: " The logical conclusion, then, is that the so-called ' cheese cow,' that is, the cow which is especially good for cheese rather than for butter, does not exist, and that whenever a cow is found that is good for cheese-making purposes, the milk of that cow is equally good for the manufacture of butter." The following statement is found on page 471 of the 1895 Year-book of the United States Department of Agriculture in an article by the late Henry E. Alvord: "Cumulative evidence is unnecessary. These important truths are established, namely: The best milk makes the best cheese, and the most of it; the milk which is most profitable for butter is also the most profitable for cheese; the best butter cow is the best cheese cow." In a discussion of the same subject, Bulletin No. 9 of the New Hampshire station contains the following statements: " We are told that cows which are giving milk poor in fat and are therefore poor butter cows are great cheese cows. . . . A milk rich in fat is not only a good milk for butter but also a good milk for cheese, while the reverse is also true."

In harmony with the general tenor of the preceding statements, the investigation carried on with different breeds of cows at this Station appears to demonstrate clearly that a pound of cheese-solids can be produced at less cost in case of milk rich in fat than in case of milk poor in fat.

(7) Another highly important question has been raised in connection with the use of a casein-test in paying for milk at cheese-factories — *Is it worth the time and trouble expended on it?* It is not worth the time, if, with Dr. Robertson, Dr. Babcock and others, we believe that casein is not equal in value to fat for cheese production in relation to composition and quality of cheese. If, on the other hand, we believe that yield of cheese alone should be considered and that fat and casein are of equal value, pound for pound, in cheese production, even then we can ask the question — Are the differences caused by variation in casein worth the trouble and expense involved in making a casein-test in addition to fat? To what extent will dividends be readjusted among patrons and in what

manner? While this question can not be answered finally until results have been secured in numerous factories, we have sufficient data on hand to give a definite answer in the case of one representative New York factory for one season. We have fat and casein determinations during one factory season for each of 50 different herds of cows whose milk was taken to one cheese-factory. The analyses of milk were made every other week for each herd separately from May to October inclusive. In 23 cases, the fat-and-casein method gave a larger dividend than did the fat alone by an average of 1.6 cents for each 100 pounds of milk, the greatest difference in the case of any one patron being 5.9 cents, and the least 0.1 cent. In one case, both methods gave the same results. In 26 cases, the fat method gave higher results by an average of 1.4 cents for 100 pounds of milk, the difference varying in the case of different individuals from 5.1 cents to 0.1 cent.

The greatest difference found in favor of the fat-and-casein basis, 5.9 cents per 100 pounds of milk, would mean for an entire factory season nearly $20, assuming that this patron furnished 33,600 pounds of milk, an average of 224 pounds for 150 days, which was the actual average for each patron. Summarizing the results on this basis, we have 23 men receiving more money by the fat-and-casein method, amounting altogether, for the season, to $123.46, the increasing dividends of each varying from 33.6 cents to $19.83, and averaging $5.39. As a matter of fact, about two thirds of the money would go to 8 patrons. One patron receives the same either way. The remaining 26 patrons receive less by the fat-and-casein method than by the fat basis, amounting altogether to $123.46, varying from 33.6 cents to $17.13, and averaging $4.75 each.

On the basis of the estimated cost of $60 to $75 spent in paying for the test, more than half of the difference ($123.46) would be used up, so that, if those who benefited by the casein-test paid for it, there would be distributed not more than half of the amount above given. This would mean an expenditure of $60 to $75, in order to adjust a difference of $123 in the interest of 23 men who furnish milk tests below the average in fat. The entire sum involved amounts to less than 0.4 per ct. of the factory's receipts from cheese. Under such circumstances, it is not at all likely that the 27 patrons would vote to employ the fat-and-casein method in distributing dividends, nor is it likely that most of the 23 men benefited would ask it, when the high relative cost of making a redistribution was understood. While the results represent only one cheese-factory,

the conditions are typical of those prevailing in New York State, and results that are strikingly different from these would probably be exceptional.

Modification of Fat-and-Casein Basis.— The fat-and-casein basis as discussed above, gives fat and casein in milk the same market value, pound for pound, for cheese production. Attention has been called (p. 293) to the proposition advocated by Dr. Babcock of giving to milk-fat a value in cheese production 6.6 times greater than to the cheese-solids not fat, which consist mostly of casein or, more accurately, of proteins derived from casein. Suppose we assign a higher value to casein for cheese production, as already suggested (p. 293), and call it worth one-fourth that of milk-fat (instead of only about one-seventh). In using this method of making dividends, one simply adds to the percentage of fat in milk one-fourth of the percentage of casein in milk and uses the numbers thus obtained in apportioning dividends. The following table indicates how the figures would run in case of average factory milk:

TABLE XIV.

Fat in milk.	Fat in milk plus one-fourth the per ct. of casein.	Fat in milk.	Fat in milk plus one-fourth the per ct. of casein.
Per ct.	*Per ct.*	*Per ct.*	*Per ct.*
3.0	3.53	4.1	4.74
3.1	3.64	4.2	4.85
3.2	3.75	4.3	4.96
3.3	3.86	4.4	5.07
3.4	3.97	4.5	5.18
3.5	4.08	4.6	5.29
3.6	4.19	4.7	5.40
3.7	4.30	4.8	5.51
..8	4.41	4.9	5.62
3.9	4.52	5.0	5.73
4.0	4.63	5.1	5.84

Dividends made on the basis of these figures would be so nearly the same as when made on the basis of fat alone, that the expense involved in a casein test would make the matter entirely impracticable under the usual conditions prevailing at cheese-factories.

PAYMENT ON BASIS OF FAT AND CALCULATED CASEIN.

In view of the fact that so many cheese-factories are still paying for milk on the basis of weight alone, as a result of the confusion that has been created in regard to the fairness of the fat basis, a

method might be suggested which would find use in factories using no test system and which would be far superior to the weight-of-milk method and at the same time possess certain advantages over other modifications of the fat basis. Such a method would be to pay on the basis of the fat and of the casein calculated according to the formula $(\text{Fat}-3)\times 0.4+2.1$. *Such a method is not recommended where the fat basis is being used, but only as a compromise where it comes to a choice between some such basis and the weight-of-milk method; in other words, where the prejudice against the fat basis is too strong to be overcome.* The amount of casein obtained thus is added to the fat and the dividends calculated in the manner given on p. 292. The use of a method basing dividends on the fat-test and the amount of calculated casein would possess the following advantages:

(1) It would be preferable to the fat-and-casein method, which requires two separate tests to be made, since no test would be needed for casein, but only for fat. It would, therefore, involve no additional expense of time, labor or money, as is the case with the casein-test.

(2) It would be more fair than the "fat-plus-two" method because milk containing higher percentages of fat would receive payment for the increased amount of casein that goes with that increased percentage of fat, instead of receiving credit for only 2 per ct. of casein, rich and poor milks alike. This method gives results that are in most cases much closer to the yield of cheese than the "fat-plus-two" method.

(3) The watering or skimming of milk could not affect the results, because the casein is made to depend on the fat content. In this respect the method is much superior to the fat-and-casein or the fat-plus-two method.

(4) No more labor need be involved than in the case of the fat basis, either in the matter of testing or in the matter of calculating dividends. The matter can be simplified by the consultation of a table, which can be made out once for all. The following formula can be used in preparing such a table:

$(\text{Fat}-3)\times 1.4+5.10=$Amount of fat and casein in 100 pounds of milk.

Such a table, already prepared, is here given:

TABLE XV.

Fat in milk.	Dividend number.	Fat in milk.	Dividend number.
Per ct.		*Per ct.*	
3.00	5.10	4.05	6.67
3.05	5.17	4.10	6.64
3.10	5.24	4.15	6.71
3.15	5.31	4.20	6.78
3.20	5.38	4.25	6.85
3.25	5.45	4.30	6.92
3.30	5.52	4.35	6.99
3.35	5.59	4.40	7.06
3.40	5.66	4.45	7.13
3.45	5.73	4.50	7.20
3.50	5.80	4.55	7.27
3.55	5.87	4.60	7.34
3.60	5.94	4.65	7.41
3.65	6.01	4.70	7.48
3.70	6.08	4.75	7.55
3.75	6.15	4.80	7.62
3.80	6.22	4.85	7.69
3.85	6.29	4.90	7.77
3.90	6.36	4.95	7.84
3.95	6.43	5.00	7.90
4.00	6.50		

(5) The introduction of the fat-test is called for by this method, and thus a great step in advance would be made in comparison with the weight-of-milk method. This might ulitmately lead to the adoption of the simple fat basis.

The following objections may be suggested to such a method:

(1) It aims to pay for the amount of cheese produced without regard to composition or quality. Of course, this same objection applies to the fat-and-casein method and the fat-plus-two method.

(2) The method of calculation may give amounts of casein differing from those actually present in milk. In individual cases and for single tests, this might be true, but, taking the average of a whole season, the differences would not usually be found great, and the season's average would be the factor on which to base a comparison as to accuracy. As a matter of fact, in the case of the 50 herds already referred to, in no case was there a difference in the season's results greater than 0.25 per ct. of casein between the calculated amount and that obtained by the chemical method, while in the case of 40 out of 50 patrons the results differed by less than 0.1 per ct., in several cases being identical.

SUGGESTIONS TO NEW YORK STATE DAIRYMEN.

On the basis of the points discussed in the preceding pages, the following suggestions are made in the interests of those dairymen in New York State who produce milk for the manufacture of cheese:

(1) The exclusive use of the milk-fat basis is advised, since it is the method which takes into consideration *composition and quality* of cheese in connection with *yield* of cheese, thus providing an equitable and simple system.

(2) The method of distributing dividends on the exclusive basis of the weight of milk delivered should be abolished, since it is open to many objections of the most serious character.

(3) In those cases in which it is found impossible to introduce the milk-fat basis, any of the following methods will be found greatly superior in fairness to the weight-of-milk system, preference being in the order given: (a) Relative values of fat and other cheese-solids, based on yield and composition of cheese, as proposed by Babcock; (b) amount of fat and calculated casein in milk; (c) fat-plus-two.

(4) The cheese-makers of New York are advised not to attempt to introduce any method of testing for casein until its practicability has been fully established beyond all doubt.

REPORT

OF THE

Department of Entomology.

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TABLE OF CONTENTS.

Control of scale in old apple orchards........................
Screening for the protection of cabbage seed beds.........
Dipping of nursery stock in the lime-sulphur wash..........
Control of leaf blister-mite in apple orchards..............
Remedies for San José scale and directions for use.........

REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

CONTROL OF SCALE IN OLD APPLE ORCHARDS.*

P. J. PARROTT, H. E. HODGKISS AND W. J. SCHOENE.

SUMMARY.

(1) This bulletin deals with experiments in old apple orchards to control the San José scale. Its purpose is to show the progress of the work and the relative cost of treatment by the more efficient remedies; and, as far as present knowledge permits, to suggest methods of affording suitable protection to fruit trees.

(2) The experiments are being conducted at Youngstown in Niagara County, Geneva in Ontario County, and Yorktown in Westchester County. Standard remedies are employed for the treatment of the main portions of the orchards, and comparative tests are made of the more promising sprays of recent introduction.

(3) The orchard at Youngstown comprises 20 acres of leading commercial varieties and the trees are 47 years of age. Scale has been present 7 years. There has been more or less spotting of the fruit. With slight exceptions, clean crops were harvested in 1907 from trees sprayed with sulphur washes and oil emulsions. Miscible oil protected trees from important injuries, but where spotting of fruit occurred the blemishes were usually more conspicuous than on trees treated with other remedies.

(4) The orchard at Yorktown consists of 20 acres and the trees are from 33 to 50 years of age. Scale has been present since 1900 and has been satisfactorily held in check by thorough applications of sulphur washes. The results in 1907 were almost perfect. The

*A reprint of Bulletin No. 296.

miscible oil was generally not so efficient in preventing the spotting of the apples.

(5) The Geneva orchard comprises 16 acres and the trees are from 30 to 50 years of age. Scale has been in the orchard for 5 years and, with the exception of 1906, has been successfully combated. In 1907, applications of sulplur washes, oil emulsions and miscible oil effectually controlled the scale.

(6) The cost of treatment per tree is variable, depending on labor, machinery, size of trees, weather conditions, kind and cost of spraying supplies and fuel, and general management.

(7) The average quantity of spray and cost of treatment per tree in these experiments, not including interest on investment and wear of machinery, are as follows:

SPRAY TREATMENT FOR SCALE; QUANTITY APPLIED AND COST, PER TREE.

NIAGARA COUNTY ORCHARD.

Trees 47 years old. Machinery, power outfits.

	Number of gallons.	Cost of treatment. Cts.
Sulphur wash, average for 1905-'6-'7........	14	31
Sulphur wash, average for 1907..............	13	27
Sulphur wash, followed with crude oil emulsion	17	38
Sulphur wash, followed with kerosene emulsion	17	38
Crude oil emulsion, 20 per ct. oil............	11	43
Crude oil emulsion, with supplementary treatment	15	54
Miscible oil, 10 per ct., at 40 cts. per gal......	10	50
Miscible oil, with supplementary treatment....	13	69
Miscible oil, 10 per ct., at 50 cts. per gal......	10	59
Miscible oil, with supplementary treatment.	13	83
Crude oil	5	58
Kerosene lime wash, 25 per ct. oil...........	15	60

WESTCHESTER COUNTY ORCHARD.

Trees 33 years old. Machinery, hand pump without tower.

	Number of gallons.	Cost. Cts.
Sulphur wash	17	66
Miscible oil, 10 per ct., at 40 cts. per gal.....	9	79
Miscible oil, 10 per ct., at 50 cts. per gal.....	9	88

ONTARIO COUNTY ORCHARD.

Trees 30 years old. Machinery, power outfits.

	Number of gallons.	Cost. Cts.
Sulphur wash	21	36
Sulphur wash, followed with oil emulsion....	22	39
Oil emulsion, 15 per ct. oil..................	8	21
Miscible oil, 10 per ct., at 40 cts. per gal.....	13	63
Miscible oil, 10 per ct., at 50 cts. per gal.....	13	77

(8) The sprays recommended for scale treatment are sulphur washes, home-made oil emulsions and proprietary miscible oils. Each of these possesses certain merits and is adapted to individual circumstances. These remedies are now generally used by fruit growers.

(9) It is conclusively demonstrated that scale can be profitably controlled on peach, plum and pear trees, and on apple trees of moderate size. Present practice indicates that old apple trees can be equally protected at a relatively nominal expense compared with the productiveness of a well-managed orchard.

INTRODUCTION.

Our fruit growers in general, by the faithful observance of the details required for the proper preparation and application of known remedies, experience no especial difficulty in controlling the scale on small trees. In many localities, while there is a full appreciation of its destructive capacity and of the danger in neglecting suitable treatment of the trees, the scale is losing many of the terrors which it formerly inspired; and annual spraying of peach, plum, pear and apple trees of moderate size for this pest is now an

established practice in the yearly routine work of many farms. Equally satisfactory and encouraging, although relatively less common, are the successful efforts of commercial fruit growers in various localities of this State in controlling the scale in large orchards of old apple trees. Unfortunately in this latter endeavor these favorable results are exceptional. The average fruit grower has not been able to afford efficient protection to his old orchards and there is usually more or less spotting of his fruit, with varying degrees of injury to the trees. This failure is felt very keenly, as the treatment has entailed much larger expenditures of money and labor than have ever been required in spraying to control other pests; and, in spite of his efforts, the fruit grower is still in real danger of losing his orchard, which constitutes one of the principal sources of income to the farm. This is the common experience in localities where the scale is well established, and it is not an infrequent complaint that the spraying of old apple trees for the scale is impracticable; as the operation is too costly, and despite the treatment it is impossible to produce marketable fruit. Disheartened by the unsatisfactory results attending their efforts, some such orchardists have now given up attempts to save the larger apple trees, which are dying. If such destruction is to continue and to become general in every community in which the scale is introduced, it will not be long before many of the older apple orchards of this State will succumb to this pest. To protect the apple trees is, to-day, the most important phase of the scale problem. The truth of this will be more highly appreciated by an increasing number of fruit growers each year, as they have opportunity to see in their own or their neighbors' orchards the destructiveness of the scale.

Realizing that the present situation with respect to the scale would probably occur, the Station, in order to ascertain what difficulties are to be overcome in the spraying of large trees, and to determine whether there are practical and economical methods of protecting commercial apple orchards, undertook, three years ago, to co-operate with a number of fruit growers in protecting their orchards, special attention being given to the old trees. The Station also sprays its own old apple orchard, according to the same plan. This serves as a check on the other experiments. It is intended to continue this co-operation until proper orchard practice for the treatment for the scale is thoroughly established throughout the State. The orchardists with whom the Station is now co-

operating are A. H. Dutton, Youngstown; Alfred Lewis, Geneva; Floyd White, Yorktown; and F. A. Sirrine, Riverhead. This bulletin deals with the progress of the experiments at Youngstown, Yorktown and Geneva. Its purpose is to show what is being accomplished in the treatment of old apple orchards; and to point out, as far as present knowledge permits, the best methods of affording efficient protection to fruit trees against the scale.

OUTLINE OF EXPERIMENTS.

METHODS.

In conducting these experiments, the orchardist largely selects his own sprays, employs his own machinery and manages the spraying for the treatment of most of the trees. The Station has in some instances assisted in preparing and applying the mixtures. As far as possible the same kinds of sprays, applied at equal strengths, are used in each orchard, that there may be a fair comparison of the results on scale and the costs of the application. For the treatment of the trees the most practicable sprays only are employed; and the kinds that are selected will vary in number each year, according as they stand the test, and as more promising mixtures are introduced. An accurate account is kept of the cost of spraying materials, amount of labor required, the wear of machinery, and various items that enter into an experiment conducted from a business point of view.

NIAGARA COUNTY EXPERIMENT.

This experiment is being made in co-operation with Mr. A. H. Dutton, Youngstown, in an old apple orchard of twenty acres, consisting of 598 trees of at least forty-seven years of age. The varieties and the number of trees to each variety are 380 Baldwins, 135 Greenings, 40 Spitzenburgs, 16 Kings, and a few summer kinds. The orchard has been regularly sprayed with bordeaux mixture containing an arsenical poison, and has been annually cultivated until the last three years, when it has been allowed to grow to sod. The trees have made an even, symmetrical growth, and are uniform in size and very productive. For these reasons the orchard is considered one of the best in the county.

HISTORY OF SCALE IN ORCHARD.

The San José scale was discovered in the orchard in 1900 upon Greenings, and in the next two years it rapidly increased in numbers, causing conspicuous injuries to many of the trees, and rendering much of the fruit unsaleable. Whole branches and an occasional large limb were killed, while the apples were conspicuously marked with red, which often appeared in more or less continuous belts or zones about the stem and calyx cavities. At that time it seemed that a goodly number of trees were beyond recovery. By 1903, the scale had spread throughout practically the entire orchard, although there were only scattered areas outside of the Greenings where the trees were much incrusted and showing evidences of injury. The first attempt to fight the scale was in 1902, when the trees conspicuously infested with scale and others in their vicinity were sprayed with the boiled lime-sulphur-salt wash. In 1903 five rows of Greenings, comprising 115 trees, were sprayed with the sulphur wash, and in the following year applications were made to individual trees in all parts of the orchard.

DESCRIPTION AND COST OF SPRAYING PLANT.

Gasoline spraying outfits, fitted with two leads of hose, with three nozzles each, are used in the treatment of orchards infested with scale. Each truck has a 20-foot tower, which, with 8-foot extension rods, has been found indispensable for the treatment of the large trees. The cooking plant consists of an 8-horse-power boiler and three tanks of about 200 gallons capacity. From the steam dome there is an overhead pipe, fitted with three downward extending arms, one to each tank. Each arm has a valve at a convenient height to control the flow of steam. Steam injectors are used to feed the boiler with water and to dilute the wash, while the spray pump is employed to convey the prepared mixture into the wagon tank.

ITEMS OF COST OF SPRAYING PLANT.

8-H. P. boiler	$90 00
3 Boiling tanks and piping	5 00
2 Gasoline power spraying outfits	450 00
Capacity of plant per day	2,500 gallons.

DETAILS OF THE CO-OPERATIVE EXPERIMENT.

In 1905 arrangements were made by the Station for a co-operative experiment in an effort to check the progress of the scale and

to determine practicable measures for treating the trees in the future. Early in the spring the orchard was severely pruned for dead and infested wood, and, especially, to remove the topmost branches, which had heretofore been difficult to spray, to render thorough treatment in the future less difficult. From 5 to 10 feet of the tops of the taller central branches were removed, the operation being made just above a vigorous-growing lateral branch. All wounds were immediately treated with red paint to assist healing and to avoid injuries by fungi and decay.

For 207 of the worst infested trees, crude oil was employed, as their condition demanded drastic treatment and the owner so desired. The oil was applied undiluted in the spring as the buds were swelling and the applications were made from two sides of the trees, which resulted in the excessive use of the oil and an over-treatment, for this spray, of many portions of nearly all of the trees. Of the remainder of the orchard, 345 trees were sprayed with the lime-sulphur wash, and 47 trees were treated with the kerosene-lime mixture, which had recently been introduced as a promising spray for the scale. The items of expense and the cost of treating the orchard with the different sprays are as follows:

COST OF SPRAYING NIAGARA COUNTY ORCHARD IN 1905.

CRUDE PETROLEUM.

Number of trees sprayed	207
20 barrels of crude oil, 1,000 gals., at $4.60	$92 00
Freight on crude oil	9 00
Three men for 3 days, at $1.50	13 50
Team for 3 days, at $2.00	6 00
Wear on sprayer	11 25
Total	$131 75
Average number gallons per tree	4.8
Cost of materials for spray, per gallon of mixture	10 cts.
Cost of oil per tree	49 "
Cost of labor and team per tree	9 "
Cost of treatment per tree	64 "

SULPHUR WASH.

Number of trees sprayed	345

3750 gallons of sulphur wash:

1125 lbs. sulphur at 2¾ cts	$30 94
1500 lbs. lime at 45 cts. per cwt	6 75
Fuel and use of cooker	3 00
1 man for 5 days at $1.50, for making wash	7 50
3 men for 5 days at $1.50	22 50
Team for 5 days at $2.00	10 00
Wear on sprayer	11 25
Total	$91 94

Average number of gallons per tree	10¾
Cost of spray per gallon, including labor of making, fuel, and wear on cooking plant	1⅓ cts.
Average cost of spray per tree, including labor of making, etc.	14 "
Average cost of labor and team per tree	9⅓ "
Average cost of treatment per tree	27 "

KEROSENE-LIME WASH

Number of trees sprayed	69

1000 gallons of kerosene-lime wash, 25 per ct. oil:

250 gallons of kerosene at 10 cts	$25 00
1000 lbs. lime at 50 cts. per cwt	5 00
Four men for 1½ days at $1.50	9 00
Team for 1½ days at $2.00	3 00
Total	$42 00

Average number of gallons per tree	14½
Cost of materials for spray, per gallon of mixture	3 cts.
Average cost of spray per tree	43 "
Average cost of labor and team per tree	17 "
Average cost of treatment per tree	60 "

TABULATED GENERAL SUMMARY FOR 1905.

In the table following a general summary is given of the data that have been presented, showing the number of gallons of each mixture used to spray one tree in this orchard, and the cost of treatment. *These figures do not include wear on machinery and interest on amount invested.*

QUANTITY OF SPRAY AND COST PER TREE.

NAME OF SPRAY.	Average number of gallons per tree.	Average cost of spray per tree.	Average cost of labor per tree.	Total cost of treatment per tree.
		Cts.	Cts.	Cts.
Petroleum	5	49	9	58
Sulphur wash	11	13	9	22
Kerosene-lime wash	14	43	17	60

RESULTS ON TREES AND SCALE BY SPRAYING IN 1905.

Crude petroleum.— The application of the crude oil killed a large percentage of the fruit buds, and many of the leaf buds, which destroyed the crop and retarded leafing for three weeks. As the season advanced, the foliage showed a surprising improvement and by August the trees appeared, on the whole, with the exception of the loss of fruit, nearly as well as the remaining portion of the orchard. A few trees, weakened by scale and collar rot, did not fully recover and apparently received a set-back, but the extent of the injuries could not be determined at that time. In comparison with the other sprays, the crude petroleum was the most effective. A very large percentage of the scales were destroyed, and the effects of the reduction were apparent for the next two years.

Sulphur washes.— The treatment with the sulphur washes caused no apparent injuries, and the trees receiving the applications of this spray bore a good crop of fruit, which with some exceptions, was quite clean and marketable. The results on the scale were, as a rule, not as satisfactory as with crude petroleum, but the general health and the fruitfulness of the trees were much better.

Kerosene-lime mixture.— This spray caused severe injuries to one side of fifteen trees in the same row, which reduced the crop and destroyed much of the foliage. It was necessary to prune these trees carefully to reshape them and to remove the dead wood. The remainder of the trees receiving this treatment produced good yields of fruit and the foliage was normal. The results on the scale were variable, but as a rule little benefit was derived from the treatment. The kerosene-lime mixture proved to be a disagreeable spray to prepare, and, when handled in quantities of 200 gallons, the capacity of the spraying tank, much difficulty was experienced in keeping the ingredients evenly distributed and in uniformly coating the trees.

DETAILS OF CO-OPERATIVE EXPERIMENT IN 1906.

In 1906 the entire orchard was sprayed in the spring, while the trees were dormant, with the boiled lime-sulphur wash. The items of expense and the entire cost of treatment are as follows:

COST OF SPRAYING NIAGARA COUNTY ORCHARD IN 1906.

LIME-SULPHUR WASH.

Number of trees sprayed	586
10,000 gallons of sulphur wash:	
3000 lbs. sulphur at 2¾ cts	$82 50
4000 lbs. lime at 45 cts. per cwt	18 00
Fuel and use of cooking plant	5 40
One man 9 days, at $1.50, making wash	13 50
Six men for 9 days at $1.50	81 00
Two teams for 9 days at $2.00	36 00
Wear on sprayer (5 per ct. on cost)	22 50
Total	$258 90

Average number of gallons per tree	17
Cost of spray per gallon, including labor of making, fuel, supplies, etc.	1 cts.
Average cost of spray per tree, including labor of making, etc.	20¼ "
Average cost of labor and team per tree	20 "
Average cost of treatment per tree	44 "

RESULTS ON TREES AND SCALE BY SPRAYING IN 1906.

At the time of blossoming there were no evidences of injury by the applications of the sulphur wash, and the general appearance of the trees was better than at any time since the summer of 1903, which was largely due to the great improvement in the condition of the Greenings. The trees were carefully examined through the summer for the first appearance of the spotting of the fruit, which was detected on a few apples on a number of trees on July 27. On August 11, the orchard was in better condition with respect to scale, at this season, than it had been for several years, and as there was very little evidence of the spotting of the apples, a clean crop of fruit was expected. But during the latter part of August, and through September especially, which was remarkably dry and warm, the scale was unusually prolific, and there was more or less spotting of the apples; but they were not, in this respect, unmarketable.

The Spitzenburgs and Baldwins in rows 7–12,* inclusive, were practically clean. The Greenings, rows 1–6,* with the exception of two trees, were much more free of the scales than in 1904, and on the whole produced a clean crop. The worst infested part of the orchard had now changed, as a result of the treatment, from the extreme eastern side, and now extended along the ditch which runs irregularly through the orchard between rows 14–17, and into the northern part of rows 21–25. The scale was kept well under control in the eastern one-half, where it had originally been very destructive. Of the trees that received the treatment with crude oil in 1905, there were five that still appeared unthrifty, the application having apparently aggravated the injuries by scale and collar rot. It should also be stated in this connection, that in the contest with the scale up to this time, no special difficulty has been experienced in preventing important injuries to the trees. Although the pest had been established in the orchard for six years, no trees have succumbed to its attacks. Of as much importance as the scale in the marketing of the crop has been the codling moth, which was responsible for many wormy apples. The control of this insect was not a part of the experiment.

DETAILS OF CO-OPERATIVE EXPERIMENT IN 1907.

In 1907, a comparative test was made of a home-made oil emulsion, containing 20 per ct. of crude oil, a proprietary miscible oil, and the boiled lime-sulphur wash. The oil emulsion was made after the standard formula and was applied to rows 7–12, inclusive. Following this treatment, a supplementary application, containing 16 per ct. oil, was applied to rows 10–12, inclusive. Miscible oil was used at the strength of one part to ten parts of water, for the treatment of rows 13–18, inclusive, and a supplementary application, at the same strength was made to rows 15–18, inclusive. The sulphur wash was applied to rows 1–6, inclusive, and rows 19–28, inclusive. Supplementary applications of oil emulsions, containing 20 per ct. kerosene or 16 per ct. crude oil, were made on portions of rows 19–28. The supplementary sprays were largely directed to the tips of the small branches and twigs to reach the scales protected by pubescence. All of the applications were made in the

*See chart, Plate XXXI.

spring while the trees were dormant and were continued until the buds commenced to burst.

The items of expense and the cost of the different sprays are as follows:

COST OF SPRAYING NIAGARA COUNTY ORCHARD IN 1907.

CRUDE OIL EMULSION (20 PER CT. OIL).

Number of trees sprayed	149	
1650 gallons of emulsion:		
330 gallons of oil at 12 cts. per gallon	$39 60	
82½ lbs. fish-oil soap at 5¾ cts. per lb	4 74	
5⅛ gals. carbolic acid at 54 cts	2 76	
2 men for 3½ days at $1.50	10 50	
1 team for 3½ days at $2.00	7 00	
Wear on sprayer	4 90	
Total	$69 50	
Average number of gallons per tree	11	
Cost of materials for spray, per gallon of mixture	2⅘	cts.
Average cost of spray per tree	31½	"
Average cost of labor and team per tree	11	"
Average cost of treatment per tree	46⅔	"

SUPPLEMENTARY TREATMENT: CRUDE OIL EMULSION (16 PER CT. OIL).

Number of trees treated	166	
600 gallons of crude oil emulsion:		
96 gallons of crude oil at 12 cts. per gallon	$11 52	
24 lbs. fish-oil soap at 5¾ cts. per lb	1 38	
1½ gallons crude carbolic acid at 54 cts. per gallon	81	
2 men for 1 day at $1.50	3 00	
1 team for 1 day at $2.00	2 00	
Wear on sprayer	1 40	
Total	$20 11	
Average number of gallons per tree	3⅔	
Cost of materials for spray, per gallon of mixture	2¼	cts.
Average cost of spray per tree	8¼	"
Average cost of labor and team per tree	3	"
Average cost of treatment per tree	12	"

LIME-SULPHUR WASH.

Number of trees sprayed	298

3900 gallons of wash:	
1170 lbs. sulphur at 2½ cts. per lb.	$29 25
1560 lbs. lime at 42 cts. per bushel	9 36
Use of cooking plant and fuel	2 10
1 man for 3½ days, at $1.50, for cooking wash	5 25
4 men for 3½ days at $1.50	21 00
2 teams for 3½ days at $2.00	14 00
Wear on sprayer	9 80
Total	$90 76

Average number of gallons per tree	13
Cost of spray per gallon, including labor of making, supplies, fuel, etc.	1.1 cts.
Average cost of spray per tree, including labor of making, etc.	15 "
Average cost of labor and team for applying the wash per tree	11½ "
Average cost of treatment per tree	30½ "

SUPPLEMENTARY TREATMENT: KEROSENE EMULSION (20 PER CT. OIL).

Number of trees sprayed	56

200 gallons of emulsion:	
40 gallons of kerosene at 11½ cts	$4 60
10 lbs. soap at 5¾ cts. per lb.	58
2 men for 2½ hours at 15 cts. per hour	75
1 team for 2½ hours at 20 cts. per hour	50
Cost of sprayer per day, $1.40	35
Total	$6 78

Average number of gallons per tree	3½
Cost of materials for spraying, per gallon of mixture	2⅗ cts.
Average cost of spray per tree	9¼ "
Average cost of labor and team per tree	2¼ "
Average cost of treatment per tree	12 "

MISCIBLE OIL (10 PER CT.).

Number of trees sprayed	116

1100 gallons of spray:		
110 gallons of miscible oil at 54⅓ cts. per gallon, including freight	$59 76	[1]$48 76
2 men for 18 hours at 15 cts. per hour	5 40	5 40
1 team for 18 hours at 20 cts. per hour	3 60	3 60
Total	$68 76	$57 76

Average number of gallons per tree..................	9½	9½[1]
Cost of spray per gallon..............................	$5\frac{2}{5}$ cts.	$4\frac{2}{5}$ cts.
Average cost of spray per tree......................	51½ "	42 "
Average cost of labor and team per tree.............	7¾ "	7¾ "
Average cost of treatment per tree..................	59¼ "	49¾ "

SUPPLEMENTARY TREATMENT: MISCIBLE OIL (10 PER CT.).

Total number of trees sprayed..................................	112

420 gallons of wash:		
42 gallons of miscible oil at 50 cts. per gal.......	$21 00	[1]$16 80
Freight on miscible oil..........................	1 82	1 82
2 men for 6½ hours at 15 cts. per hour..............	1 95	1 95
1 team for 6½ hours at 20 cts. per hour............	1 30	1 30
Wear on sprayer..................................	91	91
Total..	$26 98	$22 78

Average number of gallons per tree..................	3¾	3¾[1]
Cost of spray per gallon for materials................	5^{2} cts.	$4\frac{2}{5}$ cts.
Average cost of spray per tree......................	20⅓ "	16⅔ "
Average cost of labor and team per tree.............	3 "	3 "
Average cost of treatment per tree..................	24 "	20⅓ "

TABULATED GENERAL SUMMARY FOR 1907.

In the table following a general summary is given of the data that have been presented, showing the number of gallons of each mixture used to spray one tree in this orchard and the cost of treatment. *These figures do not include wear on machinery and interest on amount invested.*

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[1] Miscible oil purchased at 40 cts. per gallon, which is a discount of 20 per ct.

QUANTITY OF SPRAY AND COST PER TREE.

NAME OF SPRAY.	Average number of gallons per tree.	Average cost of spray per tree.	Average cost of labor per tree.	Average cost of treatment per tree.
		Cts.	*Cts.*	*Cts*
Crude oil emulsion (20 per ct. oil)........	11	32	11	43
Crude oil emulsion, with supplementary spraying with crude oil emulsion (16 per ct. oil).............................	15	40	14	54
Sulphur wash..........................	13	15	12	27
Sulphur wash, supplementary spraying with crude oil emulsion (16 per ct. oil)......	17	23½	15	38
Sulphur wash, supplementary spraying with kerosene emulsion (20 per ct. oil)......	17	24	14	38
Miscible oil* (10 per ct.)................	10	51	8	59
Miscible oil, supplementary spraying with same................................	13	72	11	83
Miscible oil† (10 per ct.)................	10	42	8	50
Miscible oil, supplementary spraying with same................................	13	58	11	69

RESULTS ON TREES AND SCALE IN 1907.

At the time of blossoming and leafing in 1907, there were no evidences of injury to the trees, attributable to the treatment of this year, by any of the various mixtures, including the supplementary applications. As the season advanced a number of the Spitzenburgs in one row treated with crude oil emulsion showed evidences of decline, as here and there on the trees there were small branches with dead foliage. But, as explained in former notes, all of these trees are badly affected with collar rot, which is largely responsible for their unfavorable condition. One of the striking features of the orchard at this season was the symmetrical and shapely appearance of the trees due to the new growth, which had filled up the gaps caused by the severe pruning in past years. With the exception of the six eastern rows, the trees yielded a good crop of fruit, the largest for several years. The effects on the scale were the most satisfactory that have been obtained in this orchard since the pest became established. As one passed through the orchard at the time of the harvesting of the fruit, the block sprayed with the home-made emulsion appeared, on the whole, to give somewhat better results on the scale than the sulphur wash, but both sprays, with the exception of less than a dozen trees in each lot, had proven very efficient, for there were very few apples that were spotted.

* Purchased at 50 cts. per gallon.
† Purchased at 40 cts. per gallon.

The block sprayed with miscible oil was the least satisfactory of any. The trees sprayed with sulphur wash once, with a supplementary treatment with home-made oil emulsions, produced fruit that was practicaly exempt from spotting by the scale. The results in detail are described in the following paragraphs:

Home-made oil-emulsions.— As stated above, this spray gave most satisfactory results, and rows 10, 11 and 12, receiving a supplementary treatment, showed no improvement with respect to the scale by the additional application, as the first spraying had controlled this pest.

Proprietary miscible oil.— The results attending the application of this oil in this orchard were very disappointing, especially because, in some of the other experiments, almost perfect results were obtained by this spray when used in exactly the same proportions. The spray, when prepared, indicated that the emulsion was stable, and in the field work efforts were made to thoroughly wet all of the bark of the trees as was done with the other sprays. The trees were dry and they were sprayed from two sides until the bark commenced to drip. The first spotting of the fruit in this orchard this season was found in the block sprayed with this oil, and at the time of harvest nearly every tree had its crop more or less spotted by the scale. There was very little improvement in this respect by the supplementary treatment.

Sulphur washes.— In the southwestern portion of the orchard a small number of trees showed more or less spotted fruit, but with this exception the trees were, as a rule, free from spotting by the scale. Now and then a tree would have a few apples with one or more spots, but the main portion of the crop was clean. The trees receiving an application of the sulphur wash and a light supplementary treatment with oil emulsion were generally free from fruit-spotting and, when judged by the size and condition of the crop and the appearance of the foliage, constituted the most satisfactory block in the orchard.

DISCUSSION OF RESULTS.

The control of the scale in this orchard has been more difficult than has usually obtained in the co-operative experiments upon this problem. The principal reasons are that the scale was well established and had encrusted many trees before the treatment of the entire orchard was practiced, and that it was necessary to train competent men to perform the requisite spraying for the scale. The

want of efficient help and the necessity of spraying in as short a time as possible, to release the men for other farm operations, have proven serious handicaps. But in spite of these obstacles, the amount of the scale in the orchard has been greatly reduced, the appearance of the trees has been much improved, and marketable fruit has been harvested. The severe pruning of the trees and the treatment of the eastern portion of the orchard with oil in 1905, are two operations which greatly facilitated later work in the control of the scale. The thorough treatment of the trees is now less difficult of attainment, while the application of the crude petroleum so completely destroyed the scale that, while two years have now passed, the effects of this spraying are still very apparent. On the basis of efficiency, cheapness and safe qualities, the boiled lime-sulphur wash and the home-made oil emulsions have proven the most satisfactory sprays, and it is believed that with annual applications of these remedies, either singly or with one supplementing the other, the scale can be efficiently and profitably controlled in this orchard. Because of its beneficial effects upon the trees, other than in the control of the scale, preference is given to the lime-sulphur wash, with a supplementary spraying, when necessary, with a 20 per ct. oil emulsion, for the treatment of the scales hidden in the pubescence of the young wood. The experience in this experiment prompts the suggestion that with care in other details in the management of the trees, equal to that directed towards the control of the scale, this orchard, as well as others in the same neighborhood, could be made much more profitable than they have been in the past. If more efficient work were done in the single operation of spraying for the codling moth, there would result increased profits which would pay in part or whole the cost of spraying for the scale.

WESTCHESTER COUNTY EXPERIMENT.

This experiment is being conducted in an orchard of 276 trees, belonging to Mr. Floyd White, Yorktown, N. Y. The larger number of the trees are about fifty years of age, while the remainder of the trees are thirty-three years old. The leading varieties are Baldwin, Gravenstein, Nonesuch, Roxbury and Rhode Island *Greening*. The orchard is regularly sprayed for the ordinary insects and plant diseases. No cultivation is given, as the orchard serves as a run for poultry. The San José scale was detected in the orchard for the first time in 1900. Because of its early infestation, this orchard was one of the first to be used for the testing of scale reme-

dies and for various experiments with the sulphur washes, having been employed for these purposes since 1901 and up to the present time. On account of the nature of the experiments, it has been necessary to leave checks or unsprayed trees, so that in no one year has the scale been entirely under control; for while it was being checked in one part, it was allowed to breed in another, according to the treatment. In 1906, the experiments were changed and the entire orchard is now sprayed with one or more of the standard remedies. Mr. White has orchards of other fruits and has been very successful in controlling the scale. No difficulty was experienced in raising crops of plums, pears and apples entirely free of scale, but in the portion of the old apple orchard given to the ex-eriments there has of necessity been more or less spotting of the fruit. Even here, when the trees have been well sprayed and are removed from the checks, clean crops have usually been harvested. The self-boiled lime-sulphur-caustic soda wash has been used for the treatment of the various orchards, and the cost of spraying the apple orchard was about 24 cts. per tree for all sizes.

DESCRIPTION AND COST OF SPRAYING PLANT.

A hand-power outfit was used, with two leads of hose with two nozzles each. The truck has no tower. A light maple pole with 40 feet of hose attached was used to spray the top part of the trees; the lower parts of the trees were sprayed, using a 6-foot pole with 20 feet of hose attached. The cooking plant consists of a 6-horse-power boiler and one tank of 160 gallon capacity.

6-H. P. boiler	$25 00
Steam pipes and fittings	5 00
160-gallon boiling vat	2 00
Gould's Sentinel pump	40 00
Spray tank (home made)	10 00
Wagon truck	35 00

In 1907 a comparative test was undertaken of the boiled lime-sulphur wash and miscible oil, the applications being made on adjacent rows of trees which were thirty-three years of age. The items of expense and the cost of spraying the apple trees are as follows:

COST OF SPRAYING WESTCHESTER COUNTY ORCHARD IN 1907.

LIME-SULPHUR WASH.

Number of trees sprayed	76
1300 gallons of sulphur wash:	
390 lbs. sulphur at 3 cts. per lb.; freight, 54 cts	$12 24
520 lbs. lime at 6 cts. per lb.; freight, 37½ cts	3 49
1 man for 23 hours at 15 cts. per hour, for making wash	3 45
3 men for 46 hours at 15 cts. per hour	20 70
1 team for 46 hours at 20 cts per hour	9 20
Wear on sprayer (2½ per ct. of cost)	1 75
Use of cooker	2 70
Total	$53 53

Average number of gallons per tree	17	
Cost of spray per gallon, including labor of making, fuel, supplies, etc.	$1\frac{3}{8}$	cts.
Average cost of spray per tree, including labor of making, etc.	28	"
Average cost of labor and team per tree	39⅓	"
Average cost of treatment per tree	70½	"

MISCIBLE OIL (10 PER CT.).

Number of trees sprayed		34
320 gallons of wash:		
32 gallons of miscible oil at 50 cts. per gal	$16 00	[1]$12 80
Freight on miscible oil	1 05	1 05
3 men for 20 hours at 15 cts. per hour	9 00	9 00
1 team for 20 hours at 20 cts. per hour	4 00	4 00
Wear on sprayer	75	75
Total	$30 80	$27 60
Average number of gallons per tree	9.4	9.4
Cost of materials for spray, per gallon of mixture	5⅓ cts.	4⅓ cts.
Average cost of spray per tree	50 "	40½ "
Average cost of labor and team per tree	38 "	38 "
Average cost of treatment per tree	90½ "	81 "

TABULATED GENERAL SUMMARY FOR 1907.

In the table following a general summary is given of the data that have been presented, showing the number of gallons of each mixture used to spray one tree in this orchard, and the cost of the treatment, *not including wear on machinery and interest on amount invested.*

[1] Miscible oil purchased at 40 cts. per gallon, which is a discount of 20 per ct.

QUANTITY OF SPRAY AND COST OF TREATMENT PER TREE.

NAME OF SPRAY.	Average number of gallons per tree.	Average cost of spray per tree.	Average cost of labor per tree.	Total cost of treatment per tree.
		Cts.	*Cts.*	*Cts*
Sulphur wash	17	27	39	66
Miscible oil*	9	41	38	79
Miscible oil†	9	50	38	88

RESULTS ON TREE AND SCALE.

The application of the sulphur wash caused no injury to the trees, and the block receiving this treatment presented throughout the summer a very pleasing appearance. The results on the scale were the most satisfactory that have been obtained in the orchards since the experiments were commenced. These trees produced yields of almost clean fruit; and it was only occasionally that an apple showing spotting was found. The results of the spraying were superior to those of former years in that all the trees were uniformly clean, which was due to the use of a wash boiled by steam in place of a self-boiled mitxure. Some of the late applications of the miscible oil severely injured the trees. These treatments were made as the young leaves were making their appearance, and they destroyed many of the leaves and the blossoms, the ill effects of which were apparent throughout the summer, in reduced numbers of fruits and less abundant foliage. The treatments with miscible oil before the buds burst caused no apparent injuries. This oil did not prove as effective as the sulphur wash; for every tree receiving this treatment showed more or less spotting by the scale. The owner of the orchard thought that possibly the trees were not as well sprayed as those treated with the sulphur wash, as it was difficult after an application of a miscible oil to determine what part of these large trees had or had not been satisfactorily wet. During the spraying operations it was intended to treat all trees thoroughly and to that end all the spraying mixture apparently required to wet all of the bark was applied.

ONTARIO COUNTY EXPERIMENT.

The apple orchard of the Station has been used for this experiment. It comprises 16 acres, including 504 trees, varying in age

* Purchased at 50 cts. per gallon.
† Purchased at 40 cts. per gallon.

from thirty to fifty-five years. Careful attention has been given to all details relating to pruning, cultivation and spraying for plant disease and insects. The San José scale was found on a few trees for the first time in the fall of 1901 after a careful examination by an official inspector. In the spring all the infested trees—which had been marked—were well sprayed with the boiled lime-sulphur wash. This proved very efficient. Subsequent inspections revealed other trees affected, which were similarly treated. No special difficulty has been experienced in completely protecting the trees, and by this method of picking out and spraying all infested trees the treatment of the entire orchard was deferred for five years. It is believed that the general treatment of the orchard would not have been necessary then, had it not been for the unfavorable results of 1906, when there was quite a little spotting of the fruit on a number of trees. This failure was due to the use of an impure grade of sulphur which was not detected by the orchard foreman until the larger number of the trees had been sprayed and the season was too far advanced to respray. From the lack of efficient treatment the scale was more conspicuous than ever before, and as the season was exceedingly favorable to its multiplication and distribution, it spread to many other trees. In the spring of 1907, to avoid taking chances, the entire orchard was sprayed with the sulphur wash, miscible oil, or oil emulsions. To afford a fair basis for comparison, the trees selected for the test were of the same age and were infested with the scale.

The items of expense and the comparative cost of spraying trees thirty years of age with the sulphur wash, oil emulsions, and miscible oil, are as follows:

COST OF SPRAYING ONTARIO COUNTY ORCHARD IN 1907.

CRUDE OIL EMULSION (15 PER CT.).

Number of trees sprayed	94
750 gallons of wash:	
113 gallons crude oil at 11 cts. per gallon	$12 43
22 lbs. whale-oil soap at 4 cts. per lb	88
2 gallons of crude carbolic acid at 54 cts. per gallon	1 08
3 men for 8 hours at 15 cts. per hour	3 60
1 team for 8 hours at 20 cts. per hour	1 60
Wear on sprayer	1 12
Total	$20 71

Average number of gallons per tree	7.9	
Cost of materials for spray, per gallon of mixture	2	cts.
Average cost of spray per tree	15½	"
Average cost of labor and team per tree	5½	"
Average cost of treatment per tree	22	"

LIME-SULPHUR WASH.

Number of trees sprayed	126
2700 gallons of sulphur wash:	
810 lbs. sulphur at 2½ cts. per lb	$20 25
1080 lbs. lime at 45 cts. per cwt	4 86
1 man 30 hours at 15 cts. per hour, for making wash	4 50
2 men 30 hours at 15 cts. per hour	9 00
1 team 30 hours at 20 cts. per hour	6 00
Wear on sprayer	4 20
Use of cooker	1 80
Total	$50 61

Average number of gallons per tree	21½	
Cost of spray per gallon, including labor of making, fuel, supplies, etc.	1 1/6	cts.
Average cost of spray per tree, including labor, fuel, supplies, etc.	25	"
Average cost of labor and team per tree	12	"
Average cost of treatment per tree	40¼	"

SUPPLEMENTARY TREATMENT: CRUDE OIL EMULSION (15 PER CT.)

Number of trees sprayed	126
100 gallons of oil emulsion:	
15 gallons crude petroleum at 11 cts	$1 65
2 pints carbolic acid at 54 cts. per gallon	14
3 lbs. whale-oil soap at 4 cts	12
3 men for 2 hours at 15 cts	90
1 team for 2 hours at 20 cts	30
Wear on sprayer	30
Total	$3 51

Average number of gallons per tree	4/5	
Cost of materials for spray, per gallon of mixture	1.9	cts.
Average cost of spray per tree	1½	"
Average cost of labor and team per tree	1	"
Average cost of treatment per tree	2¾	"

MISCIBLE OIL (10 PER CT.)

Number of trees sprayed	68

900 gallon of spray:

90 gallons miscible oil at 50 cts. per gallon	$45 00	[1]$36 00
Freight on 90 gallons of miscible oil	2 21	2 21
2 men for 10 hours at 15 cts. per hour	3 00	3 00
1 team for 10 hours at 20 cts. per hour	2 00	2 00
Wear on sprayer	1 40	1 40
Total	$53 61	$44 61

Average number of gallons per tree	13¼	[1]13¼
Cost of materials for spray, per gallon of mixture	5¼ cts.	4¼ cts.
Average cost of spray per tree	69½ "	56¼ "
Average cost of labor and team per tree	7 3/10 "	7 3/10 "
Average cost of treatment per tree	78 4/5 "	65½ "

TABULATED GENERAL SUMMARY FOR 1907.

In the table following a general summary is given of the data that have been presented, showing the number of gallons of each mixture used to spray one tree in this orchard, and the cost of treatment, *not including wear of machinery and interest on amount invested.*

QUANTITY OF SPRAY AND COST PER TREE.

NAME OF SPRAY.	Average number of gallons per tree.	Average cost of spray per tree.	Average cost of labor per tree.	Total cost of treatment per tree.
		cts.	cts.	cts.
Crude oil emulsion	8	15½	5½	21
Sulphur wash	21	24	12	36
Sulphur wash, supplementary spraying with crude oil emulsion	22	26	13	39
Miscible oil*	13	56	7	63
Miscible oil†	13	70	7	77

* Purchased at 40 cts. per gallon. † Purchased at 50 cts. per gallon.

RESULTS ON TREES AND SCALE.

No apparent injuries attended the applications of any of the sprays; and the growth and the appearance of the trees, following the treatments, left little to be desired. The sulphur wash, oil emulsion and miscible oil proved equally efficient and gave most satisfactory results on scale. Close observation was maintained on the trees throughout the summer and it was only by the most careful

[1] Miscible oil purchased at 40 cts. per gallon, which is a discount of 20 per cent.

scrutiny that eighteen trees were found, on which were several apples with not more than one or two of the usual red spots by the scale. Many fruit growers, experienced in spraying for the scale, examined the trees for evidences of this pest without success and pronounced the results perfect. Comprising, as the orchard does, trees varying from 30 to 55 years of age, on many of which the scale was abundant, this experiment is a good example of the results that can be obtained by an intelligent use of known remedies.

GENERAL SUMMARY AND CONCLUSIONS.

In the experiments described, the results in the treatments have been very encouraging. With efficient labor and adequate spraying machinery, no especial difficulty has been experienced in preventing important injuries to the trees and producing yields of fruit which have, for the most part, been unspotted. The one exception has been the Youngstown orchard where the production of an entirely clean crop of fruit has always been difficult of attainment, largely for the want of more time to respray portions of those trees which have not been well treated by the first application, and the experimental use of untested remedies. But even in this orchard, much progress has been made in the control of the scale; and a large crop of clean fruit, bringing high prices, was harvested this year. Annual spraying has reduced the amount of scale on the trees and the appearance of the orchard has been much improved. Experience, derived from our own endeavors and observations on the efforts of commercial fruit growers, demonstrates, with increasing emphasis each year, that the control of the scale on old apple trees is practicable, and that efficient protection can be afforded at a relatively nominal expense, compared with the returns from a well managed orchard.

Of the various sprays that have been tested, the sulphur wash and the home-made oil emulsions have, on the basis of efficiency, economy and safety to the trees, proven the most satisfactory remedies. Of the two, the oil emulsions have generally been somewhat more efficient than the sulphur wash in the treatment of old apple trees, and excellent results have been obtained with a light treatment of an emulsion on trees previously sprayed with the lime-sulphur wash, to reach the scales on the young wood. Either of these sprays singly or the emulsions supplementing an application of the sulphur wash, if thoroughly applied, can be depended on to control the scale. Miscible oil completely controlled the scale in one

orchard, while in the other two tests there was generally more spotting of the apples than with the other sprays. The more efficient miscible oils are among the more satisfactory substitutes for home-made remedies.

The cost of spraying apple orchards will vary from year to year and with different fruit growers. The principal factors that determine the expense are labor, machinery, size of trees, weather conditions, kind and cost of spraying supplies and fuel, and general management. The above experiments show differences in the expenditures required for each tree, which were largely determined by the cost of the remedies and the character of the spraying machinery. The average cost of the mixtures, not including the purchasing price, interest and wear of machinery are as follows: For one application to apple trees of 30 to 47 years of age, using power spraying outfits; sulphur wash, 32 cts. per tree; crude oil, 32 cts., and miscible oil, 57 cts. For one application to apple trees of 33 years of age, using hand pump without tower; sulphur wash, 66 cts. per tree, and miscible oil, 79 cts. per tree.

The above figures indicate that spraying for the scale in an old apple orchard necessitates an additional expense which will vary approximately from 30 cts. to 50 cts. for each tree. With careful management, it is believed that the cost of spraying per tree can be kept below the maximum figures. In general this expenditure represents an equivalent reduction in the customary net profits of each tree. Many fruit growers sustaining these diminishing receipts would find it possible, by better management of their orchards, to keep down the expense of distribution and cost of production, and to increase the fruitfulness of their trees by improved cultivation, fertilizing and spraying, so that the increased gains in yields alone would pay in part or wholly the cost of treatment for the scale. More efficient spraying for the codling moth would, in many orchards, have increased the value of the crop this year by at least 10 per ct., which would have paid for the needed protection against the scale. Economy is possible in other orchard practices.

The principal problem in the treatment of old apple orchards for the scale is largely one of mastering principal difficulties. There are no new principles involved. The large apple tree simply presents more serious obstacles to successful treatment than exist with other plantings. The trees are high and spreading. The pubescence of the new growth and the old bark may protect many scales.

The trees planted years ago are now too close together and impede the movements of the spraying machine. To spray a large tree well requires time and patience. To have to surmount these difficulties is a new experience for which the average operator at first is unprepared either by inclination or training. But definite progress can not be attained in the control of the scale until the old standards of spraying and spraying methods are improved upon and more thorough applications of the sprays are made. These old methods and materials gave reasonable satisfaction under the conditions originally requiring their employment; but they are inadequate under the new conditions. The chief source of weakness in much of the treatment of apple trees in the past is poor spraying, resulting from inefficient and disinterested laborers, careless supervision and inadequate spraying machinery. Most of our fruit growers who are now very successful in their efforts against this pest have had to contend with these difficulties. But as they have gained in experience and have profited by their failures and by observation of the methods of some more successful neighbor, they have gradually raised the standards of their spraying practices. With completely equipped power spraying outfits and efficient spraying crews, many of our fruit growers have developed systems of spraying adapted to their individual requirements and regularly each year spray their scale-infested trees, with no more concern, except as the insect occurs on old trees, than is felt for other important pests. Orchardists living in localities where the scale is of recent introduction, will invariably, in their first experience with this pest, meet with similar obstacles, but by careful attention to all details of spraying and with a determination to win, that can hardly fail to be inspired by the present successes of many fruit growers, they should secure reasonably satisfactory results.

PLATE XXVIII—SPRAYING AND COOKING OUTFITS USED IN NIAGARA COUNTY ORCHARD.

PLATE XXIX — METHOD OF PRUNING, AND RESHAPING OF TREES IN NIAGARA COUNTY ORCHARD.

Plate XXX — General Condition of Orchard at Harvest Time

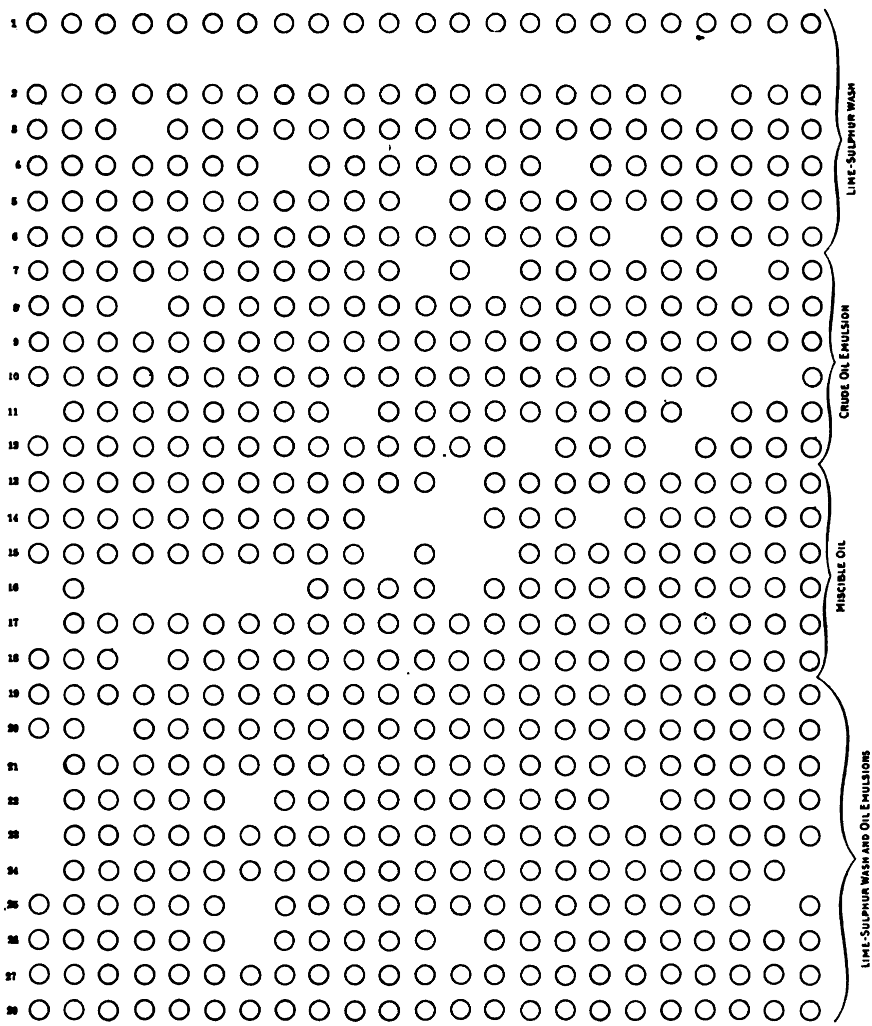

PLATE XXXI.—PLAN OF NIAGARA COUNTY ORCHARD.

SCREENING FOR THE PROTECTION OF CABBAGE SEED-BEDS.*

W. J. SCHOENE.

SUMMARY.

1. This bulletin deals with experiments to test the value of cheesecloth screening for the protection of cabbage seed-beds against injuries by root-maggots.

2. Two species attack the underground parts of seedlings, which are the cabbage-maggot (*Pegomya brassicae* Bouché) and the seed-corn maggot (*Pegomya fusciceps* Zett.). These insects are very destructive to young plants, and are pests which have been very difficult to combat successfully in seed-beds.

3. In the experiments, four large beds were made, the seed being sown respectively on April 29, May 13, May 17 and May 28. Screening was applied to 21 rows of 150 feet in length of the planting of May 13. The remainder of the bed, consisting of 68 rows of equal length, was considered as a check.

4. Plants raised under cloth grew faster and reached the desired size for transplanting one week before the seedlings in the check area. The screened sets were seasoned by the removal of the covering thirteen days before the time of replanting, and showed no more wilting when transplanted than did the check seedlings.

5. The screened bed was entirely free of maggots, and produced 50,000 sets, which were replanted. The check bed, of more than three times the size, yielded only 30,000 desirable plants. The cabbage-maggots were generally very destructive to unprotected seedlings.

6. The planting of April 29 was practically destroyed by flea-beetles and maggots. The beds sown on May 17 and 28, owing to the lateness of the season and injuries by maggots, did not produce any plants of the desired size.

7. The experiments show that screening entirely protects seedlings from injuries by maggots, and indicate that it is possible to season the plants, by removal of the covering a few days before transplanting, so as to avoid the excessive wilting and losses, which sometimes attend the planting in the field of sets grown in covered frames.

* A reprint of Bulletin No. 301.

INTRODUCTION.

In many parts of the State where late cabbages are extensively grown, farmers frequently experience much difficulty in raising enough seedlings, of required size, to plant the desired acreage. The principal handicaps in the growing of seedling plants are flea-beetles and root-maggots, which in years of abnormal numbers stunt and destroy a large percentage of the young cabbages in the seed-beds. It not infrequently happens that cabbage growers, after having sown several beds and planted several times the amount of seed ordinarily required, are finally compelled to buy plants to supply the deficiencies. On this account in various cabbage-growing sections large quantities of sets have been imported from New Jersey and Maryland for the past several years. Farmers generally are opposed to this practice and prefer home-grown plants, if they can be had, for reasons of economy and safety. It is claimed that seedlings can be grown for about ten to fifteen cents a thousand, while the usual cost of imported plants will average from seventy-five cents to one dollar and a quarter per thousand. It is also generally believed that home-grown plants are more hardy and usually recuperate quicker upon transplanting in the field; and that they do not require to be reset in such large numbers as the imported seedlings. In addition, the importing of plants or the transplanting of them from one farm to another is attended with certain risks, especially in the introduction of club-root into clean fields.

Various cabbage seed-bed problems, largely concerned with destructive insects, have been under consideration by the Station for several years. One of these is to determine means of protecting seed-beds from cabbage-maggots. Of the various measures that have been employed in the experiments with this pest, screening of the plants has afforded the most efficient protection to seed-beds. Because of its efficiency for this purpose, the attention of growers is called to the value of screening of beds as one means of protecting plants from injuries by root-maggots.

GENERAL DISCUSSION.

IMPORTANT SEED-BED INSECTS AND NATURE OF INJURIES.

Two species of flea-beetles are destructive to cabbage seedlings, which are the turnip flea-beetle (*Phyllotreta vittata* Fab.) and the smartweed flea-beetle (*Systena hudsonia Forst.*). These injure

the young plants largely by feeding on the cotyledons, which in severe attacks are often destroyed or are so severely punctured that the plants die or fail to make the required growth in time for replanting. The principal injuries by these insects occur while the plants are appearing above ground and until they are two inches in height. As the cabbages increase in size, the work of the flea-beetles in the seed-bed gradually diminishes in importance. The turnip flea-beetle is the more injurious of the two species.

Attacking the underground parts of seedlings are two species of maggots, which are the cabbage-maggot (*Pegomya brassicae* Bouché) and the seed-corn maggot (*Pegomya fusciceps* Zett.). The adults make their appearance in the seed-beds about the same time as the flea-beetles, but injuries by the maggots are usually later and the effects of the attacks are not fully apparent until after the principal work of the flea-beetles has ended. Of the two kinds of pests attacking seed-beds, the root-maggots are commonly regarded as the more destructive and the more difficult to combat.

FARM PRACTICES TO PROTECT SEED-BEDS FROM MAGGOTS.

Farmers generally are not successful in protecting their seed-beds from injuries by maggots. One of the methods most commonly recommended is to wet the ground about injured plants with diluted kerosene-emulsion or crude carbolic acid emulsion. This treatment, while destructive to young maggots, is, as commonly employed, not satisfactory. The chief reason for the failures is that the applications are made too late or are not frequent enough. Because of the doubtful results attending the use of emulsions, many growers have abandoned the employment of insecticides and now endeavor to raise the desired number of plants by making larger seed-beds, and by sowing beds at various intervals of time. These have, in the main, proven somewhat uncertain and costly practices.

A method of protecting seedling beds, which is much more efficient, is that of growing plants under cheesecloth screening. The use of screening has been tried by a few farmers, but for obvious reasons with somewhat varied success. As a rule the screened plats were not as free of maggots as they apparently should be and the plants, grown under cloth, did not usually recuperate as quickly or in as large numbers after replanting in the field as the seedlings grown in the open. Observations on various screened beds indicated that these failures could largely be obviated by making the frames entirely fly-proof, so that the insects could not get

through or under the screens, and by hardening the plants by the removal of the screening several days before transplanting. The growing of cabbage seedlings in frames for protection against maggots has not been carefully considered from all standpoints, so that there are many details regarding the raising of plants in this manner, on which more knowledge is needed.

EXPERIMENTAL.

EXPERIMENTS WITH SCREENING TO PROTECT SEED-BEDS.

To determine the value of screening as a means of protection against maggots, and to ascertain methods by which plants could be grown under frames, without appreciably reducing their vitality for transplanting purposes, some cooperative experiments were undertaken in 1907 with Mr. Levi Page of Seneca Castle. Cabbage is one of the principal crops in this part of Ontario County, and much trouble has been experienced in recent years in growing seedlings because of the severe attacks of the cabbage-maggots. As screening of beds was to be tried by a number of growers on a more or less extensive scale, a favorable opportunity was also presented, by cooperation with a number of farmers, to determine the practicability of this means of protecting seed-beds.

GENERAL CONDITIONS OF EXPERIMENTS.

The field selected for the planting of the beds consists of a rich black loam with a clay subsoil and was quite free of weeds. Previous to seeding, the portion of the field selected for the beds was heavily enriched with chemical fertilizers and was then harrowed at various intervals, as the condition of the soil permitted. Four beds were made, the seed being sown respectively on April 29, May 13, May 17 and May 28. For the purpose of this bulletin the second sowing, for which bed cheesecloth screening was used, need only be considered.

DETAILS OF EXPERIMENT WITH CHEESECLOTH SCREENING.

In this bed the seed was sown on May 13. The larger part of the seeding was made in rows twelve inches apart, using a garden drill, while for the portion intended to be screened, the seed was planted in rows only six inches apart. The number of rows included in the closer planting was 21, and the rows were 150 feet long. On May 20, this portion of the bed was enclosed. For the

PLATE XXXII.— CABBAGE SEED-BED SHOWING FRAME AND SCREENING IN POSITION AND CONDITION OF PLANTS AT REMOVAL OF SCREENING.

frame 12-inch boards were used, which were held in place by lapping the ends and by upright stakes driven in the ground. Cheesecloth was used for the covering. Four 3-foot widths were required, which were sewn to make one sheet. The cloth was fastened firmly to the frame by short nails driven through laths. To prevent sagging of the cloth, a heavy wire, supported by upright stakes, and running lengthwise of the bed, was used. All openings into the enclosed area, due to the uneven ground, were filled by banking the boards with earth.

For the purpose of comparison as to the growth of the plants and injuries by various insects, the uncovered portion of this bed, consisting of 68 rows, of 150 feet in length, may be considered as a fair check. Under this heading there may also be included some earlier and later plantings, which were also unprotected, and which may be properly referred to for the purpose of bringing out more clearly than do the real check sets, some important features of the attacks of injurious insects in the seed-beds.

RESULTS ON PLANTS IN SCREENED PLAT.

The plants in the screened area began to appear above ground on May 20, which was seven days from the time of seeding. In the interval following the sowing of the seed and the appearance of the plants, the turnip flea-beetles were present in large numbers and destroyed a large percentage of the seedlings in the earlier plantings in other parts of the field. At this date they were, however, not so ravenous and were gradually becoming less destructive in the seed-beds. Only a few of the beetles entered the screened frame, and these caused unappreciable injuries. The seeds were a little too thickly sown in the row, but as the conditions of soil as regards moisture and warmth were very favorable, the plants made a good growth. On June 20, one month after covering the frame, the screen was removed to harden the plants in preparation for transplanting. At this time the sets were quite uniform in size and averaged from about six to seven inches in height above ground, and in growth were fully one week ahead of the checks.

Upon removal of the screening, the bed was carefully examined from day to day for the eggs of the cabbage flies, the intention being to start the transplanting immediately upon the appearance of maggots, which would have allowed sufficient time to finish the work without important losses by these insects. But as no eggs were detected, the plants were allowed to become more seasoned,

and the resetting was done by machine, as is common in the field operations in this community. The number of plants, by actual count, taken from the screened bed was 50,000, which were set by July 3. As compared with seedlings grown in the open, the sets upon transplanting showed no more wilting than is usual and made a normal growth.

RESULTS ON CHECKS.

Early seeding.—This bed consisted of 63 rows of 90 feet in length and the seeding was made on April 29. Owing to the cold weather, the plants did not commence to appear above ground until May 12, when they were immediately attacked by flea-beetles, which during the following week destroyed over 50 per ct. of the planting or approximately 70,000 plants. The cabbage flies (*Pegomya brassicae* and *P. fusciceps*) were also present in large numbers and eggs were being deposited about the roots of the seedlings as early as May 29. The injuries caused by the flea-beetles, and especially by the cabbage-maggots, stunted and destroyed a large proportion of the remainder of the plants so that only a few dozens of sets were available for replanting.

Medium time of seeding: Checks proper.—This bed consisted of 68 rows of 150 feet in length and was sown on May 13. The conditions were the same as with the screened area, except that the rows were 1 foot apart and were not protected by covering. The date of the appearance of the plants above the ground was May 20, which was the same for both lots. The warm weather and frequent showers were very favorable to the plants which at the start made a good growth. A few flea-beetles were present in this bed but they did not cause important injuries. The cabbage flies were very numerous and on still warm days were very active in depositing eggs about the plants. On June 20 the first appearance of injuries by maggots was detected, and although there was no general wilting of the plants, partly due to the moist condition of the soil, an examination showed that the bed was well infested with root-maggots. During a succession of hot days in the following week these insects destroyed many seedlings and affected very appreciably the growth of the remainder of the plants, which made no material increase in size. It was estimated that at least 40 per ct. of the plants were killed by the maggots. On July 3 the plants that were still alive were much smaller than those grown under screening and, as they were generally undersized, only 30,000 seedlings were used for transplanting. The amount of seed that was sown in this

bed was considered sufficient to produce the required number of sets for planting forty acres but only a little more than four acres were actually planted.

Late seeding.—Additional beds were sown on May 17 and May 28, but owing to the attacks of root-maggots and the lateness of the season, all of the plants that survived were undersized and none were transplanted.

COST OF MATERIALS FOR FRAME AND SCREENING.

The length of the seed-bed was 150 feet and the width was 12 feet. The items of expense for materials for the frame and covering are as follows:—

ITEMS OF EXPENSE.

200 yards cheesecloth at 2¾ cts. and cost of sewing	$6 00
324 feet lumber (12 inch) at 4 cts	12 96
Laths, wire and tacks	1 25
	$20 21

The number of seedlings transplanted from this bed was 50,000, which makes the first cost of the frame and screening approximately about 40c. per 1,000 plants. Estimating that the screening could be used for three seasons, as is generally agreed, and that the boards could be used for this purpose for at least ten years, the cost of the materials for screening a bed, on the basis of these experiments, would be approximately 8 cents per thousand plants each year. The initial cost of the lumber could have been much reduced by having the frame more nearly square, rather than oblong.

OPINIONS OF FARMERS ON SCREENING CABBAGE SEED-BEDS.

The screening of cabbage seed-beds for protection against maggots has not generally proven successful. However, a number of growers during the past season covered a portion of their beds in the manner described in the Station's experiment and all have been well satisfied with the quantity and the growth of the seedlings in the screened frames.

The opinions of a number of farmers, who have reported their results, are summed up as follows: The cost of boards is not entirely considered as an item of expense; for if it were necessary to purchase a new supply, the value of the lumber for other farm

purposes is not materially lessened. All report that in the growing of plants under screening considerably less seed is needed than by the old methods to produce the required number of seedlings and some assert that this saving is sufficient to pay for the cheese-cloth. The belief is generally expressed that the screening of seed-beds in communities where the cabbage-maggot is an annual pest, is practicable and that seedlings can be efficiently protected from injuries by these insects.

SUMMARY AND CONCLUSIONS.

The experiments that have been made show that by the use of tight frames, covered with cheesecloth, cabbage sets can be grown free from injuries by root-maggots. The plants raised under cloth grow faster and in average years will probably reach the desired size for transplanting earlier than the seedlings in the open beds. The screened sets are also quite liable to be more tender, and if not well hardened, are generally more subject to wilting on replanting. Present experience indicates that the seedlings may be made more resistant to the usual injuries upon transplanting by the removal of the screening for at least one week before the time of planting, and that this seasoning may be done without much risk of injuries by maggots.

Screening of cabbage seed-beds is practiced by comparatively few growers, and usually only small percentages of the number of plants required for their purposes are at present raised under cloth. The methods that are employed in growing seedlings under screened frames often vary in minor particulars with individual farmers, and there is a diversity of opinions on such details as the grade of cloth and size of mesh to use, and the amount of seed to sow in beds to be screened, to produce the maximum number of plants, etc. More exact methods in growing sets in this manner can only be determined after more time for proof and verification. There is no question but that with screened frames, cabbage seedlings can be raised absolutely free from losses by maggots, but the practicability of the attempt, by the average grower in this State, to raise all or a large proportion of his plants under cloth, remains to be demonstrated. For this reason we would not advise, at least for the present, the extensive use of screening; but it is hoped that cabbage growers who are subject to annual losses in their seed-beds by maggots will make at least a small test to determine the value of screened frames under their own conditions. Precise instructions

can not be given in some of the details in raising seedlings by this method, as would be desirable, but observations of the practices of a number of co-operating farmers are the basis of the following suggestions to the grower who desires to test the practicability of screening seed-beds as a means of protection against root maggots.

SUGGESTIONS ON SCREENING CABBAGE SEED-BEDS.

Locate the seed-bed on a fertile and well drained piece of land, where there can be no accumulation of water or washing by rains under the frame. The ground should be free of weeds and should not have grown, the year before, cabbages or other cruciferous plants. For seed-beds it is customary to apply to the land a liberal quantity of a high grade chemical fertilizer. The seed should be drilled in rather thickly in rows six inches apart. The planting of the seed may be done at the usual season, but to avoid injuries by the flea-beetles it would be well to delay the seeding till the appearance of the beetles, which will largely have satisfied their ravenous appetites by the time the young plants appear. As the seedlings begin to show above ground, screen the bed immediately. For the frame, 12-inch boards are generally employed, which are held in place by upright stakes. To prevent the covering from sagging in the middle a heavy wire, running the length of the bed and a little above the height of the boards, and supported by stakes, is used. The screening, consisting of three or more widths of cheesecloth, sewn together to make one sheet, should be fastened to the frame by laths, through which small nails are driven. All openings into the bed, due to the unevenness of the ground, should be filled up by banking the boards with earth. To season the plants before transplanting, the screening should be removed one week or ten days before the time of setting. In this interval of time examinations should be made occasionally about the stems of the young plants near the surface of the ground for eggs, deposited by flies coming to the bed from the outside. When any are discovered transplanting in the field should commence.

DIPPING OF NURSERY STOCK IN THE LIME-SULPHUR WASH.*

P. J. PARROTT, H. E. HODGKISS AND W. J. SCHOENE.

SUMMARY.

Dipping in the lime-sulphur wash is a method of treatment proposed for the disinfecting of nursery stock for such pests as the San José scale, woolly aphis and other destructive insects. Its utility for these purposes has not been thoroughly established, and more knowledge on the safeness and efficiency of this treatment has been desired. This bulletin is a contribution of additional data, which are based on experiments to determine: (1) The effectiveness of the lime-sulphur wash as a dip on the San José scale, and (2) the effects of dipping in this mixture upon the health of nursery trees.

Tests were made of the standard lime-sulphur wash at temperatures of 60°, 100°, 120°, and 212° F. For purposes of comparison, experiments were also made with kerosene emulsion, containing 10, 15, and 20 per ct. of oil; miscible oil diluted with 10, 15 and 20 parts of water; and hydrocyanic acid gas at the rate of 0.3 gram of potassium cyanide per cubic foot. The stock used for these tests was 180 3-year old Bartlett pears and 970 3-year old Ben Davis apples, all of which were infested with the San José scale; and 300 Mann apples, 470 Bartlett pears, 300 Satsuma plums and 300 Fitzgerald peaches, all of which were clean and healthy trees.

Immersion in the lime-sulphur wash at temperatures ranging from 60° to 120° F. and for time periods varying from instantaneous dipping to immersion for ten minutes gave uncertain results on the scales. When heated to 212° F. the wash killed the scales and caused severe injuries to buds and bark, which ruined the trees. The wetting of the roots of fruit trees by this wash was generally accompanied with injuries. These were especially severe with Fitzgerald peaches and Ben Davis apples, of which 95 per ct. and 96 per ct., respectively, were killed. The treatment, by immersion of the tops of apples, pears, peaches and plums, for less than three minutes in the sulphur wash, at temperatures of 60° to 120° F., was usually unattended with appreciable injuries.

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* A reprint of Bulletin No. 302.

In the field experiments, the preparations of the oil emulsion and miscible oil caused no apparent harm to any of the trees, even when the roots were immersed. The emulsions containing 15 per ct. and 20 per ct. of kerosene, or miscible oil diluted with 10 and 15 parts of water, were more efficient as dips on the San José scale than the sulphur wash. In laboratory tests conducted later, trees were frequently severely injured by the immersion of their roots in emulsions containing 20 per ct. of kerosene. Fumigation with hydrocyanic acid gas completely destroyed the scales and the treatment was not harmful to the trees.

The results of these experiments indicate that dipping of nursery trees in the standard lime-sulphur wash for the purpose of destroying the San José scale is a doubtful practice. Nurserymen are advised to continue the use of fumigation with hydrocyanic acid gas, which is the more efficient means of freeing dug nursery stock of this pest.

INTRODUCTION.

With the introduction of the San José scale as a nursery and orchard pest, some system of official supervision of nurseries, which had in view control of this insect, became imperative. To this end, nursery inspection laws, designed principally to prevent the distribution of the scale by the trade and to protect innocent purchasers, were enacted in many states. The official inspection and certification of nurseries that followed, and the growing practice of intending purchasers of buying only of responsible firms, have awakened nurserymen generally to the necessity of affording suitable protection to their plants and of selling only clean and reliable stock. To meet the demands of the trade for protection against the scale, fumigation of nursery stock before shipment with hydrocyanic acid gas was put into practice with the passage of the inspection laws, and has been generally recognized as the most efficient method for the general treatment of the common injurious insects of dug nursery trees.

DIPPING FOR THE TREATMENT OF NURSERY STOCK.

Within recent years, interest in the dipping of nursery stock in contact sprays has been revived as a means of insect destruction as an alternative treatment for fumigation as commonly practiced. The mixture generally suggested for the purposes of a dip is the lime-sulphur wash, because of its efficiency as a spraying mixture

for the San José scale, and its valuable fungicidal qualities for various fruit diseases. The advantages claimed for this treatment by immersion, although they have not been well substantiated, are its convenience and general adaptibility for the purposes for which fumigation with hydrocyanic acid gas would be employed. This method of treating nursery stock has not been officially recognized, except by the Oregon State Board of Horticulture,[1] which, at the request of the nurserymen of that state, annulled on October 8, 1906, Rule 8 of the quarantine regulations, requiring nursery stock to be fumigated, and substituted in its place a provision which compelled dipping in a standard solution of the lime-sulphur wash. Present interest in the probable utility of this treatment in actual practice is largely the result of the adoption of this rule.

PRESENT STATUS OF DIPPING AS A MEANS OF DISINFECTING NURSERY STOCK.

Dipping of nursery stock in various contact sprays is not a new practice and has long been employed for various purposes by nurserymen, especially for the treatment of scions and budding sticks. With the appearance of the San José scale as a nursery pest, the immersion of infested trees in strong liquid insecticides was naturally, in view of existing practices, one of the first methods to be suggested and to be officially tested, to determine the value of the more promising sprays then in use, as disinfectants for this pest.

Upon the discovery of the San José scale in nurseries on Long Island in 1894, Mr. F. A. Sirrine[2] of this Station directed some extensive experiments on the treatment of nursery stock, by immersion of trees in strong preparations of whale-oil soap, which was then regarded as the most efficient spraying insecticide for this insect. The results were not entirely successful and the failures were attributed to careless work in the dipping operations. Dipping of purchases of trees, before planting, in soap mixtures is still practiced by some fruit growers as a means of precaution, to prevent the introduction on their premises of destructive insects such as scales and root-inhabiting lice.

In recent years, with the growing interest in this treatment, a number of experiments have been undertaken to determine the

[1] Oreg. Bd. Hort., Bien. Rpt. 9: 120. 1905-6.
[2] Ann. Rept. of this Station, 14: 612. 1895.

utility of the newer and more efficient spraying mixtures for dipping purposes. Prof. C. P. Close[1] of the Delaware Experiment Station, has made some extensive tests to ascertain the effects of immersing fruit trees in oils, oil emulsions and the lime-sulphur wash. The results of these tests indicated the danger of wetting roots with contact sprays. The tops of the trees, especially of apples, proved much less sensitive to injury. In 1904, Mr. F. W. Faurot[2] dipped a number of trees in the lime-sulphur wash with slight losses. A test was again made in the following year with twenty-five apples and twenty-five peaches. None of the apples sustained injuries while four of the peaches were killed. A portion of this loss was attributed to adverse conditions in planting.

Dipping of nursery trees in the lime-sulphur wash has been practiced quite extensively in Georgia, and the results have apparently been satisfactory. An experiment conducted by Prof. Wilmon Newell[3] indicated, however, that injuries might follow this treatment; and on the basis of his results, warning was given to fruit-growers of the possible damages to young trees by this practice. Dr. G. F. Warren[4] made a test with 100 Mountain Rose peaches, to determine the effects of dipping in the lime-sulphur wash on the health of the trees. One lot of trees was immersed in the lime-sulphur wash of double strength. No apparent injuries attended the treatment, even when the roots were immersed. In an experiment conducted by Prof. J. L. Phillips,[5] of Virginia, apple trees allowed to remain in the standard lime-sulphur wash at temperatures of 60° to 120° F. for five minutes, sustained only slight injuries. The effects of the dipping on peaches were much less favorable, for many trees died as a result of the treatment. Immersion in this wash did not entirely rid the plants of the scales.

Dipping of nursery trees in liquid sprays is not generally practiced by nurserymen and fruit-growers, and its use seems to be largely experimental. There is very little definite knowledge of the real advantages to be derived from this practice and of the conditions under which immersion of plants can be safely employed.

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[1] Del. Sta. Ann. Rpts., 15: 137; 16, 17 & 18: 48. 1903–1906.
[2] Mo. Fruit Sta., Bul. 14. 1906.
[3] Ga. Bd. of Ent., Bul. 14, p. 30. 1904.
[4] N. J. Sta. Bul. 197, p. 14. 1906.
[5] Va. Hort. Soc. Ann. Rept., 11: 105. 1906.

EXPERIMENTS IN DIPPING MADE AT THIS STATION.

OBJECTS.

The experiments reported in this bulletin were undertaken for the purpose of contributing further data on the value of dipping in the lime-sulphur wash for the treatment of nursery stock infested with the San José scale. The principal factors to be considered in determining the utility of the mixture for this purpose are its efficiency and safeness. In this inquiry, efforts were largely directed toward ascertaining: (1) The effects of the treatment on the scale, and (2) the effects of the treatment on the trees.

The ultimate aim of this work is to determine the value of the more efficient spraying mixtures for the disinfection of nursery trees for the common injurious insects. This information is especially sought for by fruit-growers, who are gradually realizing the desirability of treating their own purchases of stock before planting, for woolly aphis, peach aphis, San José scale, etc. A safe and efficient dip for these purposes would encourage the fruit-grower to rely more on his own efforts to protect the trees and less on the nurserymen, and would aid in dispelling the present uncertainty and confusion that now attends the placing and filling of orders for nursery stock.

OUTLINE OF THE EXPERIMENTS.

For the experiments 970 Ben Davis apples, 300 Mann apples, 650 Bartlett pears, 300 Satsuma plums and 300 Fitzgerald peaches were used. The trees were three years old. The Ben Davis and Bartlett stocks were generally well infested with the scale while the remainder of the trees were clean. The standard lime-sulphur wash was used for the larger number of the experiments, but comparative tests were also made with kerosene emulsion, containing 10, 15 and 20 per ct. of oil, with miscible oil diluted with 10, 15 and 20 parts of water, and with fumigation, using potassium cyanide at the rate of 0.3 gram per cubic foot. In the dipping operations the trees were immersed singly. For the main portion of the experiments, the temperature of the spraying mixtures was 60° F. To determine the effects of higher degrees of heat and prolonged immersion on both scales and trees, tests were made with these mixtures at temperatures varying from 60° to 212° F., and with time periods varying from instantaneous dipping to immersion for ten minutes. To ascertain the effect upon the health of the plants of wetting roots with the sprays, in most cases half the trees in each

lot were dipped with the exception of the roots and the others were wholly immersed. In each experiment checks were reserved of each variety for purposes of comparison, to note the effects of the various treatments upon the scales and the health of the trees.

THE EFFECTS OF DIPPING ON THE SAN JOSÉ SCALE.

EXPERIMENT NO. I.

INFESTED BEN DAVIS APPLES DIPPED IN SULPHUR WASH OF DIFFERENT TEMPERATURES.

The principal object of this experiment was to determine the effects of dipping trees in the lime-sulphur wash, heated to various temperatures, upon the San José scale. The trees used for this test were Ben Davis apples of three years of age, which were moderately encrusted with the scale. While the scale was in conspicuous numbers on them, the trees appeared to be vigorous and showed no appreciable signs of injury other than the usual discoloration of the cambium layer. The trees selected for treatment were dug from the nursery row on April 4, suitable protection being immediately given from the sun and the wind. They were dipped during the following day in the lime-sulphur mixture, prepared after the standard formula. The trees were dormant and showed no signs of growth other than a slight swelling of the buds.

For the dipping operations, four preparations of the standard lime-sulphur wash, with temperatures of 60°, 100°, 120° and 212° F. respectively, were made. Four lots, of thirty trees each, were quickly plunged into the respective preparations of the wash and instantly withdrawn. Immediately after they were dipped the trees were "heeled in;" and on May 6 were planted 18 inches apart in rows 4 feet apart. They were afterward cultivated according to nursery practice.

Results on scale.— On July 5, active lice were discovered for the first time for the season. All the lots, exclusive of those dipped in the wash at 212° F., had a few trees on which there was an occasional active scale. The majority of the trees showed no signs of larval activity. On August 14 the lice were more numerous and there was quite a little sprinkling of scales on the trees that were originally much more encrusted. A few trees in each lot were free of scale. As a result of the treatment, a large percentage of the old infestation had weathered off, and the bark of the trees was quite clean, and in marked contrast to the checks, which were much encrusted. An examination of the trees on September 8 showed

that about one-third of them, not including the lot dipped in the wash at 212° F., were clean, while the remaining two-thirds showed an infestation which varied from 2 per ct. to 35 per ct. of that previous to the treatment. The lot dipped in wash heated to 212° F. were entirely cleaned of scales but were much injured. The injury was especially apparent on the younger growth.

EXPERIMENT NO. II.

INFESTED BEN DAVIS APPLES DIPPED FOR DIFFERENT TIME PERIODS IN A SULPHUR WASH.

The purpose of this experiment was to determine the effects of immersion for different periods of time upon the San José scale. Six lots of trees, each comprising 30 well-infested Ben Davis apples, were used. One lot was simply plunged into the wash and immediately withdrawn, while the others were immersed respectively for one, two, three, five and ten minutes. The temperature of the sulphur wash was 60° F.

Results on scale.— The trees were examined at regular intervals to determine the effects of the treatment on the San José scale. On July 5 a few larvae were found on a number of trees in all of the lots. During August there was a slight increase in the numbers of the scales, but in no instance was the new infestation conspicuous. As compared with the condition of the trees before dipping there was a marked reduction in the numbers of the scales. The moderately infested trees were as a rule quite clean, and larval activity was usually most prominent on the trees that were originally the most infested. Taking the trees as a whole, there was very little difference in the amounts of scale destroyed by dipping for the various time periods. In all of the lots there were some trees that were clean and others that showed varying degrees of infestation, which was sometimes as much as 35 per ct. of that at the time of the treatment.

EXPERIMENT NO. III.

INFESTED BARTLETT PEARS DIPPED IN SULPHUR WASH FOR DIFFERENT TIME PERIODS.

The details of this experiment are the same as the one just preceding, differing only in that 180 Bartletts were used in place of the apples. All the trees were well infested with the scale.

Results on scale.— In all of the lots there were trees which showed on July 5 more or less breeding of the scale. By September 8 there was no apparent difference in the conditions of the trees

in the various lots. Some trees were clean and the others, although the numbers of the scales were much reduced, showed varying degrees of infestation.

EXPERIMENT NO. IV.

INFESTED BEN DAVIS APPLES DIPPED IN VARIOUS SPRAYS.

This experiment was a comparative test of various sprays to determine their merits for the treatment of nursery stock by dipping. The mixtures employed were the standard lime-sulphur wash; kerosene emulsion containing 10, 15, or 20 per ct. of oil, and miscible oil at the rate of 5, 6⅔ or 10 per ct. Hydrocyanic acid gas was used for the purpose of comparing its effectiveness with the liquid sprays. For the fumigation, 0.3 gram of potassium cyanide per cubic foot was used. The temperature of the mixture was 60° F. Seven lots of trees were dipped in the respective preparations, and one lot of thirty trees was fumigated.

Results on scale.— The effects of the different treatments on the scale, as shown by observations on July 5, August 14 and September 8, are briefly summarized in the accompanying table.

TABLE I.— EFFECTS ON SCALE OF DIPPING BEN DAVIS APPLE TREES IN VARIOUS REMEDIES.

REMEDIES.	No. of trees.	DATES OF OBSERVATION.		
		July 5.	August 14.	September 8.
Sulphur wash.......	120	Few active scales..	Sprinkling of scales, some trees clean	Some trees clean. Others with quite a few scales.
Kerosene emulsion (10 per ct. oil).	16	No active scales...	Few active scales..	Some trees clean. Others with a few scales.
Kerosene emulsion (15 per ct. oil).	16	An occasional scale.	An occasional scale.	Trees usually clean. Very few scales.
Kerosene emulsion (20 per ct. oil).	66	No active scales...	Rarely a young scale.	Two trees showing few scales. Other trees clean.
Miscible oil (1-10)...	10	Except on one tree no signs of active scales.	Rarely an active scale.	Three trees with few scales. Other trees clean.
Miscible oil (1–10)...	40	No active scales...	Few young scales..	Several trees clean. Others with few scales.
Miscibile oil (1–20)..	10	Few active scales..	Quite a few active scales.	Some trees clean. Others with sprinkling of scales.
Hydrocyanic acid gas	18	No active scales...	Scales apparently all dead.	No signs of living scales.
Checks............	30	Quite a few active scales.	Many active scales.	Trees well encrust'd

None of the liquid treatments entirely destroyed the scales and there was more or less breeding, which varied according to the spray and the dilution employed. The most efficient of this class of remedies were the kerosene emulsion containing either 15 or 20 per ct. of oil, and miscible oil, diluted with either ten or fifteen parts of water. The stronger preparations of these two mixtures gave almost perfect results, as there were only two trees treated by the former and three trees treated by the latter, which showed any larval activity, and that was very slight. Of the trees dipped in the sulphur wash some were free of scales and others were more or less infested. Of the treatments to which the trees were subjected, fumigation with hydrocyanic acid gas was the only one that effectively checked the breeding of the scales.

THE EFFECTS OF DIPPING ON FRUIT TREES.

EXPERIMENT NO. V.

BEN DAVIS APPLES DIPPED IN SULPHUR WASH AT DIFFERENT TEMPERATURES.

The purpose of this experiment was to determine the effects of dipping in the lime-sulphur wash upon fruit trees. The variety used was the Ben Davis apple, of which there were 120 trees, divided into 4 lots of 30 trees each. Four preparations of the standard lime-sulphur wash were made, which were maintained at temperatures of 60°, 100°, 120° and 212° F. respectively, during the dipping operations. In the treatment of the trees, each lot was first equally divided, and one-half the trees were entirely dipped in the mixture, while the others were immersed with the exception of the roots. Dipping was instantaneous.

Results on trees.— The effects of dipping upon the trees and the behavior of the trees following the treatment are plainly indicated by the following brief notes, which are based on observations made on the dates given.

LOT 1. TEMPERATURE 60° F.

ONLY TOPS DIPPED.

May 22. Trees leafing. Some buds retarded on all of the trees and a number of trees are much more backward than others.
June 5. Foliage fair. Trees backward, because of a late spring.
July 5. Trees normal, with abundant foliage, and making good growth.

TOPS AND ROOTS DIPPED.

May 22. Trees leafing. General conditions as above on same date.
June 5. Foliage about same as above but not quite so abundant. Some leaves are wilting.
July 5. Three trees are alive and twelve trees are dead.

LOT 2. TEMPERATURE 100° F.

ONLY TOPS DIPPED.

May 22. Conditions as above.
June 5. Conditions as above.
July 5. Trees normal.

TOPS AND ROOTS DIPPED.

May 22. Condition of trees generally as above.
June 5. Every tree shows signs of decline.
July 5. All trees dead.

LOT 3. TEMPERATURE 120° F.

ONLY TOPS DIPPED.

May 22. Same as preceding.
June 5. Same as preceding.
July 5. Trees normal.

TOPS AND ROOTS DIPPED.

May 22. All trees show retardation of buds.
June 5. Trees show evidence of decline, leaves wilting and falling.
July 5. All trees dead.

LOT 1. TEMPERATURE 212° F.

ONLY TOPS DIPPED.

May 22. Many buds killed. Leaves are very few in number.
June 5. Tips of branches are dead. Amount of foliage reduced.
July 5. All trees show evidences of injury by much cracking of bark, small growth and less abundant foliage.

TOPS AND ROOTS DIPPED.

May 22. Four trees are apparently dead. Many buds have been killed Foliage is scanty. Bark is much cracked.
June 5. All trees in rapid decline.
July 5. All trees dead.

Summary of results.— Instantaneous dipping of the tops of trees in the sulphur wash at temperatures of 60°, 100° and 120° F. caused no appreciable injuries. Complete immersion of the trees, including their roots, was in nearly every case attended with the decline of the plants within three weeks of leafing. Of sixty trees that were entirely dipped, 57, or 95 per ct. of the number treated, died as a result of the roots being wetted by the mixture. The dipping of the tops of the trees in boiling preparations destroyed many buds and caused much cracking of the bark. Trees wholly immersed in the boiling wash were killed. All of the checks, thirty in number, lived and made a satisfactory growth.

EXPERIMENT NO. VI.

BEN DAVIS APPLES DIPPED FOR DIFFERENT TIME PERIODS IN A LIME-SULPHUR WASH.

This experiment was to ascertain the effects upon nursery fruit trees of immersion for different time periods in the lime-sulphur wash. . Apples of the Ben Davis variety were used. There were 180 trees, divided into six lots of 30 trees each. For dipping, each lot was first equally divided, and 15 trees were wholly immersed and the remaining 15 trees were dipped, leaving the roots untreated. The temperature of the wash was 60° F. The time periods were instantaneous immersion and dipping for one, two, three, five and ten minutes respectively.

Results on trees.— The effects of the treatments are briefly as follows:

LOT 1. IMMERSION.

TOPS ONLY.

May 22. Trees leafing.
June 5. Foliage fairly abundant.
July 5. Trees normal, with healthy foliage and vigorous growth.

TOPS AND ROOTS.

May 22. Trees leafing as above.
June 5. General condition of trees same as above, only some leaves are wilting.
July 5. Three trees are alive and 12 trees are dead.

LOT 2. DIPPED ONE MINUTE.

TOPS ONLY.

May 22. Trees leafing.
June 5. Trees in foliage, showing small losses of leaf buds and slight twig injuries.
July 5. Trees in excellent condition.

TOPS AND ROOTS.

May 22. Trees normal.
June 5. Trees are dying.
July 5. All trees are dead.

LOT 3. DIPPED TWO MINUTES.

TOPS ONLY.

May 22. Six trees are normal and 9 trees are very backward.
June 5. Fourteen trees are in full foliage and 1 tree dead.
July 5. Fourteen trees are normal and 1 tree is dead.

TOPS AND ROOTS.

May 22. Trees are more backward than the above. Retardation of buds is very marked.
June 5. All trees are declining.
July 5. Fifteen trees are dead.

LOT 4. DIPPED THREE MINUTES.

TOPS ONLY.

May 22. Four trees show normal foliage and 11 trees have leaves reduced in size. There are some dead twigs. Small losses of buds.
June 5. Trees are making good growth.
July 5. Trees are normal.

TOPS AND ROOTS.

May 22. Four trees with slightly smaller leaves than the above. Remainder of trees show considerable retardation and injuries to bark and buds.
June 5. All trees are declining.
July 5. Thirteen trees are dead and 2 are barely alive.

LOT 5. DIPPED FIVE MINUTES.

TOPS ONLY.

May 22. Six trees are normal and 9 trees show retardation and small losses of buds, and a few dead twigs.
June 5. With exception of small amount of dead twigs and slight reduction in number of leaves, the trees are normal.
July 5. All trees are in a thrifty condition.

TOPS AND ROOTS.

May 22. Eight trees are normal and 7 trees are backward, with losses of buds and twig injury.
June 5. All trees are declining.
July 5. All trees are dead.

LOT 6. DIPPED TEN MINUTES.

TOPS ONLY.

May 22. Trees are in leaf and are making a uniform growth. The leaves average smaller than those on trees in the lots dipped for short time periods.
June 5. Trees are normal, with only slight injuries to buds and bark.
July 5. Growth of trees is normal, but foliage is not quite so abundant as that of the preceding lots when tops only were dipped.

TOPS AND ROOTS.

May 22. Three trees are normal. Remainder of trees with uneven growth and buds are barely bursting. Slight losses in buds and some injury to twigs.
June 5. All trees are declining.
July 5. All trees are dead.

Summary of results.—As in experiment V, the immersion of the roots of Ben Davis apples in the lime-sulphur wash invariably resulted in the death of a large number of the plants. Of ninety that were wholly dipped, 85 trees, or 94 per ct. of the number treated in this manner, were killed. Dipping of the tops of the trees was unaccompanied by important injuries. Immersion of the tops of the trees for periods of five to ten minutes seemed to cause a slight retardation of the buds, and in some instances to destroy a few buds and to injure the tips of pruned branches. All of the thirty checks lived, without showing appreciable injuries by transplanting.

EXPERIMENT NO. VII.

BEN DAVIS APPLES DIPPED IN DIFFERENT SPRAYS.

The sprays employed were the standard lime-sulphur wash, kerosene emulsion, containing 10, 15 and 20 per ct. of oil, and miscible oil in the proportions of one part to ten, fifteen and twenty parts of water. For purposes of comparison 18 trees were fumigated with hydrocyanic acid gas, using potassium cyanide at the rate of 0.3 gram per cubic foot. Each lot of trees intended for treatment by a mixture at a desired strength was divided equally, and half the trees were wholly immersed and half were dipped with the exception of the roots. The temperature of the liquids was 60° F. For the experiment 430 Ben Davis apples were dipped. In the treatment, the trees were plunged into the mixtures and instantly withdrawn.

Results on trees.—The effects of the different treatments on the trees are shown in the accompanying table:—

TABLE II.—EFFECTS ON BEN DAVIS APPLE TREES OF DIPPING IN VARIOUS SPRAYS.

TREATMENT.	No. of trees.	Results on trees.
Sulphur wash, tops only	135	No injury.
Sulphur wash, tops and roots	135	133 trees killed and two trees with slight injuries.
Kerosene emulsion (10–20 per ct. oil), tops only	30	No injury.
Kerosene emulsion (10–20 per ct. oil), tops and roots	30	No injury.
Miscible oil (10–20 per ct. oil), tops only	50	No injury.
Miscible oil (10–20 per ct. oil), tops and roots	50	No injury.
Fumigation with hydrocyanic acid gas	18	Trees normal.
Checks, no treatment	30	Trees normal.

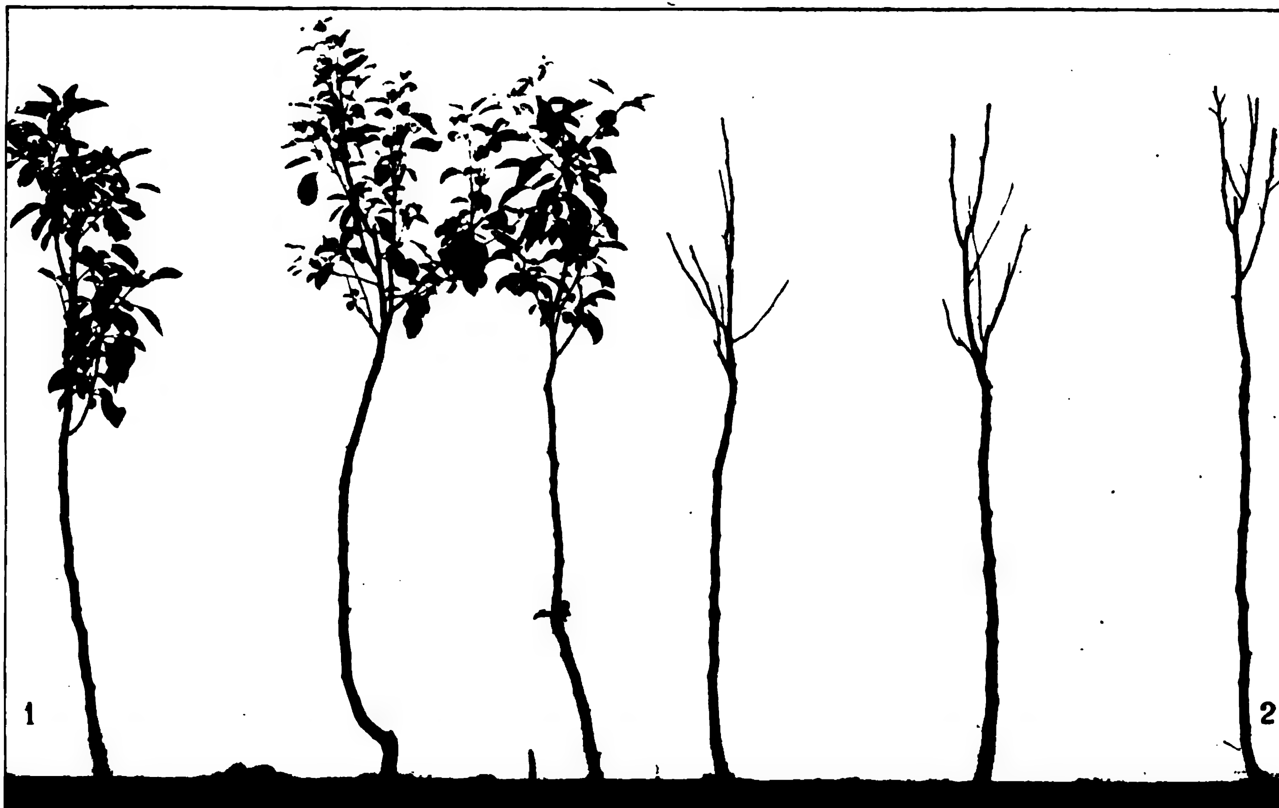

PLATE XXXIII.—BEN DAVIS APPLES DIPPED IN THE LIME-SULPHUR WASH: (1) TOPS ONLY IMMERSED, (2) ENTIRE TREES IMMERSED. CONDITIONS REPRESENTATIVE OF ALL LOTS TREATED FOR DIFFERENT TIME PERIODS.

Summary of results.— From the above table it will be seen that no injuries attended the dipping of the trees in kerosene emulsion or miscible oil in the proportions as given. The trees having their tops only immersed in the lime-sulphur wash likewise sustained no harm, while of the trees which were completely wetted with this spray, 133 were killed outright and 2 lived to make a very poor growth. The trees that were fumigated showed no appreciable injuries and made a normal growth. All of the thirty checks grew satisfactorily, without evidences of injuries by the handling and transplanting.

EXPERIMENT VIII.

BARTLETT PEARS DIPPED IN SULPHUR WASH FOR DIFFERENT TIME PERIODS.

In this experiment there were 120 2-year-old Bartlett pears divided into six lots of 20 trees. Each lot was equally divided, and half the trees were wholly immersed and the remaining ones were dipped, with the exception of the roots. The time periods were as follows:—

Lot I, instantaneous immersion, Lot II, dipped for one minute, Lot III, two minutes, Lot IV, three minutes, Lot V, five minutes, Lot VI, ten minutes. The standard lime-sulphur wash, with a temperature of 60° F., was used.

Results on trees.— With few slight exceptions, no injuries were sustained by any of the trees preceding Lot V. In Lot V, six trees that were completely immersed, died; and in Lot VI two trees similarly treated were killed. There were no losses among the checks.

EXPERIMENT IX.

MANN APPLES DIPPED IN SULPHUR WASH FOR DIFFERENT TIME PERIODS.

For this experiment 290 3-year-old Mann apples were used. The trees had been kept through the winter in cold storage and were not removed until April 27, when they were dipped. At the time of treatment the trees were dormant, with the bark and roots dry. For dipping, the trees were divided into six lots as follows: Lot I, 140 trees, instantaneous immersion, Lot II, 30 trees, immersion for one minute, Lot III, 30 trees, two minutes, Lot IV, 30 trees, four minutes, Lot V, 30 trees, five minutes, and Lot VI, 30 trees, ten minutes. Each of the above lots was divided into three parts; and for the treatment the trees in part I had the tops only dipped;

in part II had the roots only dipped; while those in part III were wholly immersed. The temperature of the sulphur wash was 60° F.

Results on trees.— The effects of these different treatments upon the trees are given briefly in detail as follows:—

LOT 1. INSTANTANEOUS IMMERSION.

TOPS ONLY.

May 22. Trees are leafing out.
June 4. Trees are making good growth.
July 5. Trees are normal.

ROOTS ONLY.

May 22. Leaves are making their appearance.
June 4. As above.
July 5. Trees are making normal growth.

ENTIRE TREES.

May 22. Trees are as above.
June 4. Ten trees are very backward. Remainder as above but some show signs of wilting.
July 5. Fourteen trees are dead. Thirty-two trees are normal.

LOT 2. DIPPED ONE MINUTE.

TOPS ONLY.

May 22. Buds are opening. Some trees are retarded.
June 4. Eight trees are in leaf. Two trees with buds just opening.
July 5. Tress are making normal growth.

ROOTS ONLY.

May 22. As above.
June 4. Four trees are in leaf. Six trees with buds just opening.
July 5. Four trees are dead. Six trees are normal.

ENTIRE TREES.

May 22. Six trees are in leaf. Four trees are much retarded.
June 4. Seven trees are making good growth. Three trees with buds unopened.
July 5. Seven trees are dead. Three trees with poor growth.

LOT 3. DIPPED TWO MINUTES.

TOPS ONLY.

May 22. One tree in leaf and nine trees with unopened buds.
June 4. Seven trees are making good growth. Three trees with buds just breaking open.
July 5. All trees are in normal condition.

ROOTS ONLY.

May 22. Same as above.
June 4. Two trees are making good growth. Eight trees with unopened buds.
July 5. Five trees are dead. Five trees are making fair growth.

ENTIRE TREES.

May 22. Five trees are in leaf. Five trees are dormant.
June 4. Eight trees are making good growth. Two trees are backward.
July 5. All trees are making fair growth.

LOT 4. DIPPED THREE MINUTES.

TOPS ONLY.

May 22. All buds are retarded, barely showing green at tips.
June 4. Four trees in leaf. Six trees with many buds unopened.
July 5. Trees are making good growth.

ROOTS ONLY.

May 22. Same as above.
June 4. Two trees are in leaf. Eight trees with buds unopened.
July 5. Two trees are dead and 8 trees are normal.

ENTIRE TREES.

May 22. Same as above.
June 4. About same as above.
July 5. Five trees are dead and 5 trees are making fair growth.

LOT 5. DIPPED FIVE MINUTES.

TOPS ONLY.

May 22. Five trees are in leaf and 5 trees with unopened buds.
June 4. Seven trees are making good growth and 3 trees are much retarded.
July 5. All trees are in fair condition.

ROOTS ONLY.

May 22. Two trees are in leaf. Eight trees are dormant.
June 4. Trees same as above.
July 5. Trees are as above.

ENTIRE TREES.

May 22. Trees are as above.
June 4. General condition same as preceding.
July 5. Four trees are dead and 6 trees are making poor growth.

LOT 6. DIPPED TEN MINUTES.

TOPS ONLY.

May 22. All trees very much retarded.
June 4. All trees are retarded and many buds are unopened.
July 5. Trees with fair quantity of leaves and showing dead stubs.

ROOTS ONLY.

May 22. Three trees in leaf. Remainder are much retarded.
June 4. All trees are showing small leaves and dead stubs.
July 5. Three trees are dead and 7 trees show fair growth.

ENTIRE TREES.

May 22. Two trees in leaf. Remainder are much retarded.
June 4. All leaves are small and some are wilting.
July 5. Four trees are dead and 6 trees show fair growth.

Summary of results.— The Mann apples, which were taken from cold storage, did not sustain quite as severe injuries as Ben Davis apples, removed directly from the field, as described in preceding experiments. Of 188 trees that had the roots treated with the sulphur wash, 48 trees, or 26 per ct. of the trees dipped, were killed. The trees that had their tops only treated showed no appreciable injuries by instantaneous immersion or dipping from one to three minutes. The trees that were dipped for ten minutes showed retardation of buds and small losses in foliage. The checks made a good growth and there were no apparent injuries to any of the trees.

EXPERIMENT X.

BARTLETT PEARS DIPPED IN SULPHUR WASH FOR DIFFERENT TIME PERIODS.

This experiment was conducted in the same manner as the one preceding. The stock consisted of 290 3-year old Bartletts taken from cold storage. The details of the dipping operations are the same as in experiment No. IX.

Results on trees.— In Lot VI, of which the tops of the trees were immersed for ten minutes, slight injuries to the buds were apparent. On June 7, the number of the leaves appeared to be reduced. Quite a number of sprouts were growing out from the sides of the trunk, just below the treated area, at the bases of the lower branches. These trees showed very little improvement by July 5. Ten trees with the roots only dipped in the sulphur wash were also injured and made very little growth. Many of the pruned branches appeared as dead stubs. The trees in the remaining lots were not affected by the treatments and with some exceptions all made normal growth. On the whole, pears sustained very little injury as compared with apples similarly treated.

EXPERIMENT XI.

SATSUMA PLUMS DIPPED IN SULPHUR WASH FOR DIFFERENT TIME PERIODS.

This was conducted in the same manner as Experiment IX. The nursery stock was taken from cold storage and consisted of 290 3-year-old Satsuma plums. All details of the dipping operations are the same as previously described.

Results on trees.— No important differences were noted in the trees of lots I to III inclusive. The effects of the treatments upon the remainder of the trees are as follows:—

LOT 4. DIPPED THREE MINUTES.

TOPS ONLY.

May 22. Trees are in leaf.
June 7. Leaves are very small and growth is poor.
July 5. Growth is good. Many tips of branches are dead and considerable sprouting shows below base of lower branches.

ROOTS ONLY.

May 22. Same as above.
June 7. Tips of branches are dead and sprouts show on trunk. Three trees are dead.
July 5. Four trees are dead. Remainder of trees have made a poor growth.

ENTIRE TREES.

May 22. Trees are in leaf.
June 7. Leaves are very small. Tips of branches are dead. Few sprouts show on trunk.
July 5. Growth is small and much dead wood appears in tops of trees.

LOT 5. DIPPED FIVE MINUTES.

TOPS ONLY.

May 22. Growth is much retarded and few leaf clusters are apparent.
June 7. Considerable sprouting shows on sides of trees and bases of branches. Tips of branches are dead.
July 5. Growth is poor. Much dead wood is apparent. Considerable sprouting shows on trunks.

ROOTS ONLY.

May 22. As above.
June 7. Leaves are larger and more abundant than above. Injuries to wood are not so extensive.
July 5. Growth is good. One tree is dead and 3 trees are backward.

ENTIRE TREES.

May 22. Trees are more retarded than above.
June 7. Six trees are declining. Four trees are in fair condition.
July 5. All trees are in very poor condition. Tops are dead. Few sprouts show on trunks.

LOT 6. DIPPED TEN MINUTES.

TOPS ONLY.

May 22. All trees are much retarded.
June 7. Tops practically killed. More or less sprouting on trunks.
July 5. Tops of trees consist entirely of dead stubs. Sprouting on trunks below branches.

ROOTS ONLY.

May 22. All trees in leaf.
June 7. Leaves in full number but are small.
July 5. Tops of trees are small and growth is poor. No apparent injuries to branches.

ENTIRE TREES.

May 22. Six trees much retarded and showing considerable injuries.
June 7. Tops dead. Much sprouting on sides of trunks.
July 5. Trees are nearly dead. Sprouts on sides of trunks are making a feeble growth.

Summary of results.— The trees in lots I to II inclusive showed very little difference in their conditions as a result of the treatment. The trees generally made a satisfactory growth. Plants immersed for three or more minutes usually sustained severe injuries. Trees with their tops only immersed had many buds and some of the wood killed. Injuries to the lower branches were followed by considerable sprouting on the trunks below the areas treated. The effects of immersion of plum roots in the sulphur wash for the longer time periods were somewhat variable, but as a rule such treatment was followed by a poor growth, resulting in many instances in the death of the trees. No injuries were apparent among the checks, of which there were thirty.

EXPERIMENT XII.

FITZGERALD PEACHES DIPPED IN SULPHUR WASH FOR DIFFERENT TIME PERIODS.

The details of this experiment are the same as described for experiment IX. For the treatment, 300 3-year-old Fitzgerald peaches, taken from cold storage, were used. The details of the dipping operations are as described in preceding experiments.

Results on trees.— The injurious effects of the treatments were generally more pronounced on the peaches than on other kinds of fruit. The results in detail are briefly as follows:—

Lot 1. Instantaneous Immersion.

TOPS ONLY.

May 22. All trees are dormant.
June 7. Growth is good.
July 5. Trees in excellent condition.

ROOTS ONLY.

May 22. All trees are dormant.
June 7. Fifty-three trees are dead. Ten trees are apparently alive.
July 5. Fifty-eight trees are killed. Five trees show poor growth.

ENTIRE TREES.

May 22. Trees are dormant.
June 7. Trees show little life.
July 5 thirty in number, are dead.

Lot 2. Immersed One Minute.

TOPS ONLY.

May 22. Trees are dormant.
June 7. Trees are as good as checks.
July 5. All trees show good growth.

ROOTS ONLY.

May 22. Trees are dormant.
June 7. All trees are as good as checks.
July 5. All trees, ten in number, are dead.

ENTIRE TREES.

May 22. Trees dormant.
June 7. All trees are dead. Trees are sprouting near ground.
July 5. All trees, ten in number, are dead.

Lot 3. Immersed Two Minutes.

TOPS ONLY.

May 22. Trees are dormant.
June 7. Good growth but little inferior to checks.
July 5. Trees are in excellent condition.

ROOTS ONLY.

May 22. Trees are dormant.
June 7. Tops are dead. Four trees show young sprouts on trunks.
July 7. Seven trees are dead. Three show live sprouts on trunk.

ENTIRE TREES.

May 22. Trees are dormant.
June 7. Tops are killed. Nine trees show sprouts on trunk.
July 5. All tops are dead. A few sprouts near the ground appear on all of the trees.

LOT IV. IMMERSED THREE MINUTES.

TOPS ONLY.

May 22. Trees are dormant.
June 7. Some buds are killed. Leaves are few. Many sprouts appear on trunks.
July 5. New growth is heavy. Old branches are dead. Many sprouts show on trunks.

ROOTS ONLY.

May 22. Trees are dormant.
June 7. Three trees are dead. Seven trees show a few leaves and sprouts appear on trunks.
July 5. Four trees are dead. Six trees have small tops and poor growth.

ENTIRE TREES.

May 22. Trees are dormant.
June 7. All trees are alive. Tips of branches are dead. Many sprouts show on trunks.
July 7. Growth is small. Old branches are dead.

LOT V. IMMERSED FIVE MINUTES.

TOPS ONLY.

May 22. Trees are dormant.
June 7. Six trees show dead tops. Three trees have few leaves and sprouts on trunks.
July 5. All tops, 10 in number, are dead. Considerable growth of sprouts appears on trunks.

ROOTS ONLY.

May 22. Trees are dormant.
June 7. All tops are dead. Five trees with sprouts on sides of trunks.
July 5. All trees, 10 in number, are dead.

ENTIRE TREES.

May 22. Trees are dormant.
June 7. Nine trees are dead. One tree is barely alive.
July 5. All trees, ten in number, are dead.

LOT VI. IMMERSED TEN MINUTES.

TOPS ONLY.

May 22. Trees are apparently dormant.
June 7. All tops are killed. Much sprouting appears on sides of trunks.
July 5. Tops of trees are dead. Long growth of sprouts near surface of ground.

ROOTS ONLY.

May 22. Trees are apparently dormant.
June 7. All trees are apparently killed.
July 5. All trees, ten in number, are dead.

ENTIRE TREES.

May 22. Trees are apparently dormant.
June 7. All trees are apparently killed.
July 5. All trees, ten in number, are dead.

Summary of results.— The peaches generally proved very much more susceptible to injuries by complete or partial immersion in the lime-sulphur wash than any of the other kinds of fruits that were tested. Injuries to the buds were caused by the dipping of the tops in the mixture for periods of three or more minutes, and the tops of the trees were killed by immersion for ten minutes. Trees with their roots immersed in the lime-sulphur wash were seriously injured or killed by the treatment. Of 188 trees that were dipped with the roots 179, or 95 per ct. of the number treated, were killed. All of the checks, thirty in number, made a normal growth.

ROOT INJURIES BY IMMERSION IN SPRAYING MIXTURES.

The trees with roots immersed in the sulphur wash frequently sustained injuries. The effects of this treatment upon the health of the plants were most plainly apparent about fourteen days after the trees were in leaf. The first indications of the injuries were by the wilting and curling of a few leaves, which during a succession of hot days gradually extended to the entire foliage. The trees that were extremely affected soon became defoliated, from which they did not revive. The growth that was made appeared to be entirely at the expense of the reserve food material which had been stored up in the main axis of the plants.

An examination of the underground portions of a number of trees dipped in the wash showed that the root system may be seriously damaged by this treatment. The extent of the injuries was not constant and varied with individual plants of the same variety. Cross sections of immersed roots, which externally exhibited no evidences of injuries, showed frequently a discolored cambium. Large portions of the tips of the older roots and often entire smaller roots were killed. In some instances the cambium was

killed in spots which gave rise to more or less extensive dead areas. Wounded areas made by the cutting of a large root sometimes did not callous and failed to produce adventitious roots.

In the field experiments with oil emulsions, there were no evidences of injuries to the trees, but in some laboratory tests, conducted later, on the immersion of roots in an emulsion, containing 20 per ct. of oil, damages resulted. The injuries were even more severe than with the sulphur wash, and were apparent about the collar as well as the roots of the plants.

GENERAL SUMMARY.

Immersion of moderately infested apple and pear stocks in the standard lime-sulphur wash was attended with variable results on the scales. None of the four lots, representing 600 affected trees, that were dipped showed complete destruction of this pest. In each lot there were individual trees on which the scale was efficiently combated, but the remainder of the stock, while deriving some benefit from the treatment, showed an infestation which varied from two per ct. to thirty-five per ct. of that previous to dipping. Preparations of washes at temperatures of 60°, 100° and 120° F. exhibited similar variations in their effectiveness on the scale, while immersion of infested trees in the wash at a temperature of 212° F. entirely killed the scales and severely injured the trees. Dipping of roots in the sulphur wash was usually accompanied by injuries which varied in extent with the kinds of stock, apples and peaches sustaining the most damage. Ben Davis apples showed a loss of 96 per ct. of the number of trees wholly dipped, Mann apples, 26 per ct., and Fitzgerald peaches, 95 per ct. The treatment of the tops of apples and pears by instantaneous dipping or immersion from one to five minutes in the wash at temperatures of 60° to 120° F., generally caused no important injuries. Mann apples and Bartlett pears apparently sustained slight damages to buds by immersion for ten minutes. The dipping of the tops of peaches and plums in a sulphur wash at temperatures of 60° to 120 F., for less than three minutes, was unattended with appreciable injuries, while immersion for longer periods of time seemed in some instances to destroy many buds. The tops of peaches were killed by immersion for ten minutes in the lime-sulphur wash at a temperature of 60° F.

In the field tests with kerosene emulsion, containing 10, 15 and 20 per ct. of oil, and miscible oil, diluted with 10, 15 and 20 parts

of water, to determine their value as dips, no injuries were apparent to any of the trees, even when the roots were immersed in the liquids. These proved not only safer but the stronger preparations were also much more effective on the scales than the sulphur wash. Kerosene emulsion, containing either 15 or 20 per ct. of oil, and miscible oil, diluted with either 10 or 15 parts of water, were generally very efficient. With the exception of a few trees on which there was a little breeding, the stock was cleaned of the scales. Fumigation with hydrocyanic acid gas at the rate of 0.3 gram of cyanide per cubic foot caused no appreciable harm to the trees and completely destroyed the scales.

DISCUSSION OF RESULTS AND CONCLUSIONS.

The purpose of these experiments was to determine the merits of the standard lime-sulphur wash as a dip for the treatment of nursery trees. In this endeavor, efforts were principally directed to determine the safeness of dipping trees in this mixture and the probable effects of this operation in field practice accomplishing the real object of the work, i. e., to clean the stock of San José scale. The experiments have yielded data bearing on both of these points, which show plainly that the immersion of the roots of fruit trees in a sulphur wash may be accompanied with serious injuries to the stock, and that this treatment does not entirely destroy the scales. In view of these limitations, it is believed that this method of disinfecting nursery trees is a doubtful practice for both nurserymen and fruit-growers, neither of whom can afford to take chances on the reliability of their purchases and shipments. In the light of these experiments, uncertain and disappointing results could hardly fail to follow the employment of this kind of treatment for nursery stock. Until more knowledge is obtained of the strength of the sulphur wash that will effectively control the scale, dipping of the tops of trees in this mixture for purposes of disinfection should be regarded as wholly experimental. As immersion of the tops of the trees in the standard sulphur wash at temperatures of from 60° to 120° F. for short time periods is unattended with important injuries, it is possible that stronger preparations of the sulphur wash can be employed for the treatment of stock, excluding the roots, which will give efficient results on the scales and will not prove harmful to the plants.

The results obtained with the oil emulsions and miscible oils indicate that they are more efficient for dipping purposes than is the

sulphur wash. Their actual value for this purpose and the conditions under which they may be safely employed are problems for future experimentation.

The fact that fumigation with hydrocyanic acid gas, in addition to proving safe to the plants, was the only one of the remedies employed that completely destroyed the scales, deserves special emphasis. This process is the most efficient means of disinfecting nursery stock and its utility for this purpose has been abundantly established by many experiments and by the experience of careful nurserymen. While it is not an absolute guarantee of the immunity of the trees from destructive insects, it is without question the most effective method of accomplishing their destruction. Its efficiency and safeness are proportionate to the care that is exercised in carrying out the details of the operation. For dug dormant stock, infested with the San José scale, fumigation is the more reliable treatment.

CONTROL OF LEAF-BLISTER MITE IN APPLE ORCHARDS.*

P. J. PARROTT.

SUMMARY.

Conspicuous spotting of foliage by the leaf blister-mite is general throughout the apple-growing areas of western New York. The continued attacks of this pest for successive years affect unfavorably the growth of the trees in the worst infested orchards, and, while the losses are not easily measured, crop yields are unquestionably being reduced in proportion to the severity of the infestation and according to the character of the management of the orchard.

The mite spends the winter under the bud scales and it is most susceptible to treatment during the late fall when the majority of leaves have dropped or during the spring before the new foliage appears. The efficient remedies for the blister-mite are the lime-sulphur wash, oil emulsions and miscible oils. Orchards that are regularly sprayed with these mixtures are not subject to injuries by the mite.

Comparative tests of the boiled lime-sulphur wash, the home-made concentrated lime-sulphur wash, and two commercial preparations gave equally satisfactory results. One application of either of these sprays has practically prevented spotting of foliage by the mite.

With the increased availability of the sulphur sprays these are now practicable remedies for the treatment of apple orchards for the blister-mite. In employing these remedies for this purpose, a plan of spraying well adapted for the treatment of apple trees is an application of a sulphur wash as the buds are swelling and before the leaves appear, followed by the usual second and third applications of the bordeaux mixture in their proper season.

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*A reprint of Bulletin No. 306.

INTRODUCTION.

The general spotting of apple foliage by the leaf blister-mite has for several years been of annual occurrence. By reason of its conspicuous work in apple orchards, the mite is now regarded by our fruit growers as a pest of growing importance to the fruit interests of this State. With the exception of the San José scale, there has been no insect for the past three years which has generally attracted more attention or which has provoked more discussion among growers in western New York, as to its probable destructiveness to apple trees and as to the more efficient methods of control, than has this mite.

The appearance of the blister-mite in the apple orchards of this State was announced in Bulletin 283, which directed the attention of fruit growers to the effectiveness of oil emulsions, miscible oils and the home-made lime-sulphur wash for its control. Since the distribution of this bulletin, the Station has continued its experiments, especially those to determine the value of various sulphur sprays for the treatment of the mite, as a basis for more complete directions to orchardists who should desire to spray for this pest. While special treatments for the mite have been made by relatively few orchardists, the opinion is generally expressed that it would pay to spray rather than to take further chances with the worst infested orchards. According to the reports of fruit growers, spraying for the mite will be quite generally practiced in many localities this coming spring.

ECONOMIC IMPORTANCE OF MITE.

DISTRIBUTION AS AN APPLE PEST.

The work of the mite is now quite common throughout the apple-growing sections of western New York. It has been very conspicuous in the orchards generally in Orleans, Monroe, Genesee, Wayne, Livingston, Ontario, Yates, Seneca and Steuben counties. Badly diseased leaves have been received by the Station from apple orchards at Pattersonville in the Mohawk Valley and from Delmar, Voorheesville and Schodack Landing in the Hudson Valley. Mr. Percy Huested, a State nursery inspector, has also noted apple trees with the leaves much spotted by the mite at Preston Hollow in the Catskills.

Injuries to apple foliage have been recognized in Massachusetts and Pennsylvania. Mr. E. Cyrus Miller, Haydenville, Mass., in-

forms us that the mite has been quite a serious pest in apple orchards in his vicinity and at Leyden. Prof. H. A. Surface of the Pennsylvania Department of Agriculture states that spotting of apple foliage by the mite occurs in practically all portions of Pennsylvania. It seems to be generally distributed, but is overlooked or is not recognized by fruit growers. Mr. W. J. Schoene, while engaged in nursery inspection in Illinois, recognized the work of the mite in apple orchards in the southern part of that state, but Dr. Forbes has written me that its injuries have not been of sufficient importance to attract attention. Prof. T. D. Jarvis of the Ontario Agrcultural College has also reported outbreaks of the blister-mite in apple orchards in the Province of Ontario, Canada.

It is a pest wherever pears are grown, and is probably widely distributed on apples, although its work on apple foliage seems not to be as common as on pears or as destructive as it is at present in the leading areas of apple production of western New York.

EFFECTS ON CROP YIELDS.

The actual damage to apple orchards by the mite cannot be accurately determined, and figures on the effects of its attacks on crop yields are largely conjectural. Not infrequently injuries by the mite have been confused with the work of other destructive agencies. The unfavorable conditions of some orchards, said to be damaged by the mite, may be more justly charged to several contributory causes, such as poor drainage and injuries by winter and by various insects and spraying mixtures.

Orchards that are subject to an adverse environment, through lack of fertility, improper methods of tillage or droughty conditions of weather, usually show very plainly the effects of the mite, while closely adjoining plantings, which are grown in well-drained, fertile soil and given the needed tillage to stimulate a vigorous growth, may largely outgrow injuries by the first attacks in the spring and produce good yields. During 1908 it was quite generally observed that timely rains favored the development of new foliage and in spite of early fears of losses by the mite, apples were abundant and of uniformly larger size than for several years.

Fruit growers whose trees have been much infested believe that the mite has caused more or less dropping of the young fruits, and that the general infestation of the foliage lowers the vitality and productiveness of the trees and injures the leaf and fruit buds for the next year's crop. In badly infested orchards, especially where

other conditions have not been favorable, the mite has unquestionably influenced unfavorably the production of crops, as the foliage could not be diseased to such a degree without the vitality of the trees being affected. This influence, while not easily measured, has undoubtedly in a good many orchards been important, but in general there has been a tendency to overrate the actual damages by the mite.

EXPERIMENTS IN CONTROLLING THE LEAF BLISTER-MITE.

The experiments described under this heading were undertaken by the Station in its own orchards or in co-operation with several fruit growers who had desired to spray for the blister-mite. All of the orchards, preceding the spraying tests, were badly infested with the mite and they afforded excellent opportunities for determining the relative merits of the different spray mixtures, and of demonstrating to fruit growers on a commercial scale efficient methods for controlling this pest. Each orchard is discussed separately and it has been intended to give in condensed form an accurate idea of the conditions and results of the experimental operations.

ORCHARD I.

As has been the experience of fruit growers generally in Ontario County, the Station apple orchard has also been infested with the leaf blister-mite. In 1906 pimpling of young apples and blistering of leaves were very conspicuous, especially on several trees of the variety Williams, which were for two years badly affected and have apparently sustained important injuries. During that year, 250 varieties were recorded as showing more or less of the work of the mite. Some of the leading commercial varieties which had their foliage badly diseased were the Baldwin, Rhode Island *Greening*, Sutton, Fall Pippin, Ben Davis and King. The work of the mite was largely confined to the younger apple orchard, which comprises 6 acres and contains 218 trees.

In this orchard experiments have been made to determine the comparative merits of sulphur washes, oil emulsions and miscible oil for the control of the leaf blister-mite. In the spring of 1907 the orchard was divided into three areas, and each area has been treated with the same spraying mixture for the past two years. For purposes of comparison some applications of each insecticide were made in the fall, but the larger proportion of the spraying has

been done in the spring when the buds are swelling, ending when the tips of the young leaves began to make their appearance. The sulphur wash was prepared after the standard formula, while a commercial preparation of this mixture was employed at a dilution of one part to nine parts of water. Miscible oil was used at the rate of one gallon diluted with nine gallons of water, while the kerosene emulsion contained 15 per ct. of oil.

In addition to spraying entire blocks, comparative tests of these remedies have been made on individual trees, which were among the worst infested on the Station grounds. Each tree was divided into thirds, fourths or fifths, according to the number of mixtures tested, and provision was also made for checks. To confine a particular treatment to the portion of the tree desired and to avoid re-treatments while applications of the various remedies were being made on other parts, cloth screens were employed in all of these operations.

Results on mite.—The first year's applications of these remedies destroyed a large percentage of the mites. During the summer of 1907, the work of the mite on the sprayed trees was very slight as compared with that of the previous year or that on the checks. None of the trees was completely free, but enough of the mites were killed to prevent the pimpling of young apples and to protect a large percentage of the foliage from injury. The applications in the fall of 1907 and the spring of 1908 were equally effective and the foliage in this orchard, with the exception of a few leaves on an occasional twig, was generally very clean. The smaller tests also indicated that, if the applications are equally thorough, there is very little difference in the effectiveness of the different sprays. The results of these experiments show conclusively, also, that the blister-mite is never likely to cause important injuries in orchards that are well sprayed each year with a sulphur wash or oil emulsions as is required for the proper treatment of the San José scale.

ORCHARD II.

This orchard belongs to E. C. Green, Victor, and comprises about ten acres. There are 465 trees, which are 30 years of age. The leading varieties are Baldwin, Seek-No-Further, Wagner and Spy. The orchard has been systematically sprayed for the common insects and diseases and is regarded as one of the most attractive and productive plantings in the community. Originally the orchard was given very thorough cultivation, but for the past two years it

has been grown under the so-called sod-mulch method. This change seems to have been an unfortunate one; as the sod treatment, combined with the blister-mite and two comparatively dry seasons, has told seriously on the health of the trees.

The blister-mite did not attract the attention of the owner till 1905, when the foliage of nearly all of the trees was generally conspicuously spotted. During succeeding years the mites have continued to be abundant, especially on Baldwins, and owing to the unsatisfactory condition of the orchard during 1907, a co-operative experiment with this Station was undertaken this spring to demonstrate the value of the home-made concentrated lime-sulphur mixture for the control of the mite. The applications of this wash were made with a power sprayer during the week of April 5–11. At this date the buds were well swollen and were beginning to show green at the tips. The trees were thoroughly whitewashed by the one operation and no other treatments were made. The quantity of mixture used to each tree was seven gallons. A number of Baldwins were left unsprayed to serve as checks.

Results on mite.— The results of this treatment were among the most conclusive in the series of experiments. The difference in the conditions of the sprayed and unsprayed portions of the orchard was very striking. The foliage of the sulphur-treated trees was entirely free of mite injuries and made a very marked contrast with adjacent rows in the untreated parts of the orchard Not only were the leaves free from diseased areas, but they seemed on an average, to be somewhat larger than those on the unsprayed trees. This may have been mainly due to the absence of curling, one of the results of the attacks of the mite. The sprayed trees appeared to have made a better growth and, consequently, to carry a heavier foliage, but this difference was perhaps more apparent than real. The leaves of unsprayed trees in this community generally showed very plain evidences of infestation with the blister-mite.

ORCHARD III.

This is the orchard of Wm. A. Lafler, Albion. It consists of 17 acres, bearing 260 trees, 45 years of age and 323 trees, 35 years old. The older trees have been largely grown in sod, which has been heavily manured, while the younger planting has been under thorough cultivation. Both plantings have yielded well for the past twelve years. The leading varieties are Baldwin, Greening, Russet, Spy, King and Twenty Ounce. The orchard has been

regularly sprayed for the ordinary insects and plant diseases and has in all respects been given excellent care.

The mite made its appearance in destructive numbers for the first time in 1906 in the younger orchard, and in 1907 it was abundant in the older orchard. The varieties that have shown the work of the mite most extensively are the Baldwin and Gilliflower. The owner estimates that the mite has caused a decreased yield in the younger orchard amounting to about 250 barrels each year. The condition of the foliage of the Gilliflower was worse than that of the Baldwins and all of the fruit was of little value, as it was much undersized. This was attributed to the work of the mite. For the treatment of the trees the home-made lime-sulphur wash and a commercial concentrated preparation of this mixture were employed. The applications were made during the week of April 13–20. The amount of wash applied per tree was ten gallons, which was larger than necessary because of the treatment of the trunks and large limbs. These could have safely been left unsprayed. A power sprayer was used to make the applications. Several Baldwins and a block of 23 Hubbardstons were left unsprayed as checks.

Results on mite.— The effectiveness of the sulphur wash for the control of the blister-mite in an old commercial apple planting was in none of the experiments more strikingly demonstrated than in this orchard. While there were occasional twigs that showed some affected leaves, the foliage generally was clean, and, as in other experiments, the appearance of the trees afforded a striking contrast with the condition of the checks, which as usual were abundantly infested with the mite. Mr. Lafler is so much impressed with the efficient qualities of the sulphur wash as an orchard spray that he has erected a steam cooking outfit, and plans to make one treatment of this mixture each year during the dormant season in place of the usual application of the bordeaux mixture at that time. The home-made wash and the commercial concentrated preparations of the lime-sulphur wash were equally effective in controlling the blister-mite.

ORCHARD IV.

This orchard belongs to C. Willard Rice, Seneca, and comprises six acres. The number of trees is 180 and they are about 40 years of age. The varieties are principally Baldwin, Greening and King. This orchard has been cultivated for the past eight years and treated with barnyard manure and chemical fertilizers. The yields have averaged about 400 barrels each year. Injuries to foliage

by the mite have been noticed for four or five years, and the Greenings have been the variety most affected. The owner reports that the worst infested trees suffered more or less premature dropping of the foliage, and believes that this partial defoliation has retarded the growth of the trees. It is also thought that through the unsatisfactory condition of the leaves there have been some losses in the crop yields by the dropping of young fruits and the failure of the apples to attain full size.

For the treatment of the trees the home-made concentrated lime-sulphur wash, diluted with nine parts of water, was used, and the application was made on April 11. The buds were generally well swollen and many were beginning to show green at the tips. The spraying was carefully done; on drying, the trees appeared to be competely whitewashed. The quantity of mixture applied to each tree averaged from seven to eight gallons. Hand-power machinery was employed. Several trees of each variety were left unsprayed which served as checks.

Results on mite.— Judging from the condition of the foliage of the checks, the mites were not generally as abundant in this orchard as in the preceding year. The trees showed a marked variation in the quantity of diseased leaves; while some trees were quite seriously affected others were almost free of injuries or had only a small proportion of the leaves spotted by the mite. These differences in the condition of the checks preclude an exact estimate of the benefits derived by the trees sprayed with the lime-sulphur wash. But in comparison with the checks the work of the mite on the sprayed trees was uniformly less conspicuous and there were none of those striking differences in the amount of infestation of the foliage so apparent on the untreated portions of the orchard. Spotting of the foliage was largely limited to occasional leaves or to clusters of leaves on widely separated branches. It is reasonable to suppose that while some other agency may perhaps have checked the work of the mite in certain parts of the orchard the uniform freedom of the sprayed block from injuries by the mite must be largely attributed to the treatment with the lime-sulphur wash. As noted in Orchard II it was also observed in this experiment that owing to the reduction in the quantity of diseased leaves, the foliage of the sprayed trees presented a more thrifty appearance, and the new growth was apparently more heavy than that on the checks.

VOLUNTEER EXPERIMENTS.

While there is a widespread complaint of the unsatisfactory appearance of the foliage of apple trees through the work of the blister-mite, spraying has not generally been practiced for this pest. This has not been for the lack of desire, as owners of badly infested orchards are generally of the opinion that they would spray, if only they knew what spray to employ and were assured that the treatment would be profitable. The remedies that efficiently control the leaf blister-mite are comparatively untried sprays for the majority of our apple growers, who are not accustomed to spray for the scale; and they hesitate to adopt new spraying practices. Kerosene emulsion, it is true, is an old and well-known insecticide, but it has never been extensively employed, outside of the San José scale areas, as farmers dislike the bother of making it. Miscible oils are new insecticides and their merits and their uses are not generally recognized. The recent agitation concerning the San José scale has made the lime-sulphur wash well known by name, but the reputation of this insecticide among fruit growers who are not familiar with the methods of preparing and handling it, is, usually, that the mixture is a disagreeable spray.

For the purpose of making available the experience of various orchardists and of pointing out what they have accomplished in their first efforts in spraying for the mite, in order to encourage others in a similar effort, it was thought desirable to include in this bulletin a discussion of the more important details of these operations. These are designated "volunteer experiments" as they have been largely planned and carried out by the fruit growers themselves. To them belongs the credit,— not to the Station. In compiling these experiments, the facts have been stated precisely as they were given to us; and, for purposes of accuracy, a copy of the manuscript discussing his experiment was also furnished to each orchardist for correction and approval.

For the sake of brevity the reports have been very much condensed, but as far as possible the more important items needed to convey a fairly accurate description of the conditions and results of the experiments are given. The experiments are designated by numbers and are arranged in the order of their location, commencing with the Hudson Valley, and continuing through the leading apple-growing counties of western New York.

EXPERIMENT NO. 1.

This experiment was undertaken by H. B. Vincent, Old Chatham, Columbia County. The orchard includes 30 acres, planted to 1200 trees, which vary from 3 to 14 years of age. The leading varieties are Baldwin, Spy, Greening, Oldenburg and Boiken apples and Bartlett pear. The older trees are systematically sprayed with the bordeaux mixture and the orchard is tilled and grown in grass in short rotation. The blister-mite has been present in conspicuous numbers in the orchard for one year, when the Baldwins were most affected. It is not believed that important injuries were sustained by the outbreak. An application of the lime-sulphur wash was made on March 18, and about five gallons were used for each tree. The blister-mite is reported to be not very injurious to apples in this community.

Results on mite.— The applications of the lime-sulphur wash in this experiment proved very efficient, and with slight exceptions the foliage was entirely free of injuries by the mite.

EXPERIMENT NO. 2.

This experiment was conducted by Berlin H. Wright, Penn Yan, Yates County. The orchard, of 4 acres, contains 100 Baldwins which are 20 years old. The usual spraying with the bordeaux mixture is practiced. The larger portion of the orchard has been tilled, and the foliage and fruit have been so superior to that of the untilled trees, that hereafter the entire planting is to be given thorough cultivation. Extensive spotting of the foliage by the mite occurred last year for the first time. The owner believed that the injuries to the leaves caused some fruits to drop and reduced the size of the mature apples, and thus lessened the crop yield. The trees were sprayed with the lime-sulphur wash in March and again in April. The mite is reported as increasing in destructiveness in this community.

Results on mite.— The applications of the lime-sulphur wash were very effective. No pimpling of young apples was detected and the foliage was practically exempt from spotting by the mite.

EXPERIMENT NO. 3.

Conducted by B. J. Case, Sodus, Wayne County. The orchards comprise about 25 acres, planted to 640 trees, which vary in age from 26 to 55 years. The principal varieties are Baldwin, Green-

ing, Twenty Ounce, Russet, King and Pound Sweet. The orchard is thoroughly sprayed, cultivated and fertilized, and bears well every year. The blister-mite has been noticed in conspicuous numbers for three or four years. The varieties that have shown the most spotting of the foliage are Baldwin and Russet. The mite has caused important injuries. For the experiment 60 Baldwin trees of 27 years of age were sprayed with a commercial brand of concentrated lime-sulphur wash, diluted with twelve parts of water. A power sprayer was employed. The mite is gaining in importance in this community.

Results on mite.— The application of the lime-sulphur wash was very efficient. There was only an occasional spotted leaf, and the trees, on the whole, were practically clean. As noted in other experiments the sprayed trees presented a very thrifty appearance which showed up in marked contrast with the untreated portions of the orchard.

EXPERIMENT NO. 4.

Conducted by H. W. Stoddard, Pultneyville, Wayne County, The orchard has an extent of 2½ acres and consists of a miscellaneous lot of apples, of which Baldwin and Greening are the leading varieties. The usual spraying with bordeaux mixture is practiced, and with the exception of the past four years the trees have been thoroughly tilled since 1895. Conspicuous injuries by the mite were detected for the first time last year. Baldwins have been most affected. The mite has caused some damage to the orchard but the extent of injury is largely conjectural, because of other varying conditions. The lime-sulphur-salt wash was employed but it was only applied to one side of the trees, because of failure to obtain a favorable wind to complete the spraying. The treatment was made with a power pump on April 24, as the buds were breaking and about two and one-half gallons were applied to one side of each tree. The mite is becoming more destructive in this community.

Results on mite.— The application of the lime-sulphur-salt wash largely prevented spotting by the mite. The difference between the conditions of the sprayed portions of the trees as compared with the unsprayed portions and the checks was sufficient to indicate the utility of the sulphur wash for this pest.

EXPERIMENT NO. 5.

This was conducted by C. E. Taylor, Pulteney, Steuben County. The orchard comprises 3 acres, planted to 80 trees, which are 20 years old. The principal varieties are Greening, Northern Spy, Baldwin and Wagner. The orchard is given the usual spraying with bordeaux mixture, containing an arsenical poison, and has been tilled for the past two years. Injury to foliage by the mite was recognized for the first time in 1906. Baldwins have been most affected. In 1907 the mite was reported to be very destructive, causing nearly all of the leaves to fall before the fruit ripened. For the treatments, miscible oil, diluted with fifteen parts of water, was employed, and about six gallons of the spray was applied to each tree. The treatment was made on April 24, as buds were opening.

Results on mite.— Spotting of the foliage by the mite was very much reduced.

EXPERIMENT NO. 6.

This experiment was made under the direction of H. C. Pratt, Canandaigua, Ontario County. The orchard contains 12 acres and has 450 trees, which vary from 33 to 50 years of age. The orchard consists largely of Baldwin, Greening, King and Russet. The trees have been regularly sprayed and for the past five years until this season, when cultivation was practiced, the orchard has been seeded to a mixture of vetch, clover and orchard grass. Attention was first attracted to the work of the blister-mite in this orchard in 1907 when the leaves were quite badly diseased. The Baldwins have been more affected than other varieties. The foliage for this year was considerably injured and the fruit crop was small, but the owner reports that other factors had probably a greater influence in determining the yield. In the treatment of the trees a comparative test was made of the home-made lime-sulphur wash and a commercial preparation of this mixture. The treatment was made about April 15th and it is estimated that about eight gallons of either mixture was used to each tree. A power sprayer was employed to make the applications. The mite is reported as not gaining in importance in the vicinity of this experiment.

Results on mite.— Both the home-made lime-sulphur wash and the commercial preparation of this mixture completely held the mite in check. From the conditions of the foliage in both blocks, these sprays were equally efficient, and seemed in all respects satisfactory remedies for this pest.

EXPERIMENT NO. 7.

This experiment was made by H. L. Bulkley, Brockport, Monroe County. The orchard embraces seven acres, planted to 300 trees which are 34 years of age. The varieties that are largely grown are Baldwins, Twenty-Ounce, King, Greening and Spy. The trees were not productive until 1896 when the owner commenced to spray and till the orchard regularly, and to apply fertilizers. With the exception of one year, good crops of fruit have been harvested annually. The blister-mite appeared in destructive numbers in the orchard in 1905, especially on the Baldwins and the Greenings, but less on the latter than the former. In 1907 the work of the mite on the fruit was noticed for the first time and about 10 per ct. of the crop was thought to be pimpled. The blister-mite was less abundant in 1908 than during the preceding year, but generally it is gaining in importance in this community as an orchard pest. The spray used this year for the treatment of the mite was the lime-sulphur wash and only about two gallons were applied to each tree, the applications being made on April 20–22 with a hand pump. Checks were left for comparison.

Results on mite.— Notwithstanding the small quantity of wash employed there was an appreciable reduction in the amount of affected foliage on the sprayed trees. The foliage was not entirely clean, but the appearance of the treated trees satisfied the owner that a more liberal use of this spray in season would prove an effective remedy for this pest.

EXPERIMENT NO. 8.

The experiment was conducted by Wm. J. Edmunds, Sweden, Monroe County. The orchard contains about 15 acres and comprises approximately 500 trees, which are about 34 years old. Many varieties of apples are grown but a large proportion of the trees are Baldwins. The farm has been managed by tenants, who have sprayed the orchard every year, and have endeavored to keep it well tilled. The trees have been productive. The blister-mite has been in injurious numbers in the orchard for the past three years and has been especially abundant on the Baldwins. Other varieties such as Ben Davis, Cooper Market and Bellflower have also shown more or less spotting of the foliage by the mite but

usually the injuries have not been important. The owner believes that the mite has damaged his orchard, besides causing reduced fruit yields. A commercial preparation of the lime-sulphur wash, diluted with twelve parts of water, was sprayed on the trees during the last week in April. The mixture was applied with a hand pump.

Results on mite.— There was a marked difference between the foliage of the sprayed and unsprayed trees. The owner was convinced that a thorough application of the lime-sulphur wash in the spring affords efficient protection to the trees from the mite.

EXPERIMENT NO. 9.

This experiment was conducted by Roy P. McPherson, Le Roy, Genesee County. The orchard that was sprayed comprises seven acres, planted to 200 trees, which vary in age from 35 to 45 years. The more important varieties are King, Russet, Greening and Baldwin. The orchard has been cultivated almost continuously for the past ten years and has gradually increased in productiveness. The usual spraying with bordeaux mixture containing an arsenical poison has been practiced. The blister-mite made its appearance in conspicuous numbers in the orchard during the past two years, and the variety that has been most affected is the Baldwin. The Kings and Greenings have usually been less injured. The owner believes that the diseased condition of the foliage has lessened his crop yields by causing the young apples to drop, and reducing the size of the mature fruit. The spray that was employed for the treatment of of the trees was a miscible oil, diluted with fifteen parts of water. The treatment was given on April 7 and only one application was made. A power sprayer was used and the average quantity of mixture applied to each tree was five gallons. A number of trees were left as checks. The work of the mite was reported to be less prominent in this community than during the preceding year.

Results on mite.— As compared with the checks there was a marked reduction in the amount of infestation of the foliage of all the sprayed trees. The treated Baldwins were estimated to be about as one-quarter as badly infested as the checks, while the Kings and Greenings showed a much greater measure of protection.

EXPERIMENT NO. 10.

This experiment was made by Wm. L. Bradley, Pavilion, Genesee County. The orchard comprises 6 acres, planted to 250 trees, which are 33 years of age. The more important varieties are Northern

Spy, Baldwin and Colvert. The orchard has been regularly sprayed and is worked with a disk harrow each year. Spotting of the foliage by the mite has been recognized in this orchard since 1903. The Baldwins have been the most conspicuously infested of the varieties. It is stated that the attacks of the mite affected the growth of the trees and reduced crop yields. Kerosene and crude oil emulsions, made with whale oil soap and diluted with ten parts of water, were used for the treatment of the orchard, and about three gallons of spray were applied to a tree. The treatment was made on April 14 with a power sprayer. The blister-mite was less numerous this year than in 1907, but its work is still noticeable in many orchards in this vicinity.

Results on mite.— Following the applications of the oil emulsions very little spotting of the foliage by the mite was noticed in the experimental block. It is intended to repeat this treatment this spring.

EXPERIMENT NO. II.

Conducted by Charles I. Herrington, Warsaw, Wyoming County. The orchard that was sprayed contains ten acres, and the principal varieties of apples are King, Baldwin, Russet and Greening. The orchard is now tilled but a portion of it has been in sod until the past year. Spraying with bordeaux mixture has been practiced for three years. The mite made its appearance in destructive numbers on the trees in 1907. The Baldwins have shown the most spotting of the foliage and about forty trees of this variety in the lowest portion of the orchard have sustained considerable damage. Other varieties similarly located present a much better appearance, so that it is believed by the owner that the unfavorable condition of the Baldwins is not to be entirely attributed to drainage. The trees were sprayed during the first part of April with a commercial preparation of the lime-sulphur wash, and about one and a half gallons of this spray were applied to each tree. The blister-mite is becoming more destructive in this community, especially in orchards that are not receiving careful attention.

Results on mite.— The applications of the lime-sulphur wash reduced the amount of spotting of the foliage. The owner believes that spraying for successive years with this mixture will efficienctly control the blister-mite.

SUMMARY AND CONCLUSIONS.

The results of these experiments have shown very conclusively that the leaf blister-mite is not a difficult pest to combat, and that it can be efficiently controlled by sulphur sprays, miscible oils and home-made oil emulsions. The use of these remedies for the treatment of the mite was discussed in Bulletin 283, and subsequent experiments have confirmed their usefulness for this purpose. On the basis of the experiments described, there is nothing to add with regard to the employment of oil emulsions for the mite, but the merits of the sulphur sprays for the treatment of this pest should be more fully presented than has heretofore been possible.

In the experiments with the sulphur sprays, comparative tests were made of the common lime-sulphur wash, a home-made concentrated mixture, and two commercial concentrated preparations of the lime-sulphur wash. Very satisfactory results were obtained in every orchard in which they were employed, and there was apparently no appreciable difference in the effectiveness of the various preparations on the mite when they were used under similar conditions. The measure of protection actually obtained showed, as would naturally be expected, some slight variations in the various orchards, which were probably due, largely, to differences in the standards of spraying of the fruit growers. In every test all trees that were thoroughly treated with a sulphur spray showed, in comparison with the checks, a marked diminution in the numbers of the mites, which in several instances resulted in almost complete destruction. The results show very plainly that one application dur- the dormant season, or as buds are bursting, affords efficient protection to the trees, and that the mite is not ever likely to be of importance in orchards that are annually sprayed with the lime-sulphur wash, a practice now common in many localities in this State where the scale threatens.

The attention of fruit growers is for the first time called to the merits of the home-made concentrated lime-sulphur wash, which is deserving of more extensive tests under farm conditions for spraying for the mite. This method of compounding a sulphur spray by orchardists is still in the experimental stage and probably some slight changes will be made in the future as regards the proportions of lime and sulphur and the amount of dilution. It is a convenient

method of preparing a sulphur spray and is destined to be put to important uses. This mixture has two distinct advantages over the old formula: It may be prepared in concentrated solutions, to be diluted as needed; and it has no coarse sediment to clog the nozzles and to cause the rapid wearing out of the packing, lining and other parts of the pump. However, its employment for orchard treatment, except for the blister-mite, should be largely tentative as its utility for other pests has not been so thoroughly established. This mixture and the commercial preparations now enable many of our fruit growers to use a sulphur wash, who for the reasons given have refrained from using this spray, prepared by the old method.

SULPHUR SPRAYS AND DIRECTIONS FOR THEIR USE.

THE BOILED LIME-SULPHUR WASH.

FORMULA.

Lump lime	20 pounds
Sulphur	15 pounds
Water	50 gallons

Place the lime and sulphur in the cooking receptable containing about fifteen to twenty gallons of water. Stir the mixture frequently and boil for one hour. Add water to make the required amount of wash and strain through a fine brass wire strainer into the spraying tank. Applications should be made while the wash is warm.

HOME-MADE CONCENTRATED LIME-SULPHUR WASH.

FORMULA.

Lump lime	60 pounds
Sulphur	125 pounds
Water	50 gallons

Slake the lime in the cooking receptable and stir in the sulphur, which has been made into a thin paste with water. Add enough water to make about forty-five gallons of mixture, which should be boiled for one or more hours. After the cooking is completed allow the wash to stand until the sediment has settled to the bottom, when the clear, brownish liquid should be drawn off. To this add

water if needed to make the required fifty gallons of concentrated solution.[1]

For use, dilute the concentrated sulphur solution at the rate of five gallons of the liquid to forty-five gallons of water. To every barrel of 50 gallons capacity of the diluted spray, add from ten to fifteen pounds of lime, made into a paste. The addition of the lime is not necessary, but by its use the trees are given a white-washed appearance, which enables farmers to judge better of the thoroughness of their spraying. This mixture may be used immediately after cooking, or may be barreled, to be drawn on as occasion requires. A greater dilution than that recommended may perhaps be employed in spraying for the mite. The mixture prepared after this formula does not leave as heavy a deposit on the trees as the ordinary boiled lime-sulphur wash, but in spraying for the mite this difference is immaterial. To avoid the loss of sulphur, the sediment that remains after drawing off the concentrated solution should be boiled over again with fresh lime and water, and the liquid used to start fresh preparations or for purposes of dilution. For this formula we are indebted to Prof. A. B. Cordley of the Oregon Experiment Station, who has employed it in his experiments with sulphur sprays for the treatment of trees in foliage.

COMMERCIAL PREPARATIONS OF LIME-SULPHUR WASH.

During the past year, a number of these preparations have appeared on the market. Two of the most widely advertised have been quite extensively tested in various Station experiments with the blister-mite, and at the strength employed, one part to nine parts of water, have proven very efficient remedies. A number of volunteer experimenters have reported equally satisfactory results. Fruit growers who have heretofore refrained from using the lime-sulphur wash for the mite, because of the trouble of making and the expense of a suitable cooking outfit, may now use one of the commercial brands. Usually some lime paste should be added to these preparations, as, without it, it is difficult to tell how thoroughly the applications have been made.

[1] The concentrated solution gives a reading of about 25° on a Beaumé hydrometer. Fruit growers are advised to use this instrument in order to test their preparations. A Beaumé hydrometer costs 75 cents and can be purchased from Eimer & Amend, 205 Third Ave., New York City, and from other dealers in druggists' supplies.

PLATE XXXIV.— FITZGERALD PEACHES DIPPED IN THE LIME-SULPHUR WASH: (1) TOPS ONLY IMMERSED, (2) ENTIRE TREES IMMERSED. CONDITIONS REPRESENTATIVE OF ALL LOTS TREATED FOR DIFFERENT TIME PERIODS.

DIRECTIONS FOR APPLYING SULPHUR WASHES FOR BLISTER-MITE.

Applications of the lime-sulphur wash may be made in the fall after the majority of leaves have fallen or in the spring until the buds commence to break and to show the tips of the young leaves. Treatment should not be made later than this as the sulphur sprays are very destructive to the tender foliage and the mites may have gained entrance into the leaves, where they would be beyond the reach of the mixtures. If it is desired to treat the trees in the spring, the usual spraying at this time with the bordeaux mixture is unnecessary. By following this plan the work of spraying for the mite is greatly simplified, and for this reason it is generally preferred by orchardists. Liberal quantities of the sulphur wash should be applied and the trees after treatment should have the appearance of being completely whitewashed.

REMEDIES FOR THE SAN JOSE SCALE AND DIRECTIONS FOR THEIR USE.*

P. J. PARROTT.

THE LIME-SULPHUR WASH.

The formula and directions for preparing the lime-sulphur wash are as follows:

Lump lime..	20 lbs.
Sulphur..	15 "
Water..	50 gals.

Place the lime and the sulphur in a kettle containing about fifteen to twenty gallons of hot water. Stir the mixture frequently during the cooking process to assist the chemical union between the lime and the sulphur, and to prevent the caking of the materials upon the sides of the vessel. Boil for one hour, then add hot or cold water as is convenient, to make the required amount of wash. The mixture, when properly prepared, is of an orange yellow color. For use, strain the wash through fine-mesh wire screen to remove coarse particles, and apply to the trees as soon as possible after cooking. After each day's operation, rinse the tank to remove the sediment, and pump water through the spraying outfit to clean hose and nozzles. Flowers of sulphur, and light and heavy sulphur flour may be used. Because it is cheaper the latter grade is now largely purchased. Fresh stone lime, that forms an even paste free from grit and dirt, should always be used for this wash.

TIME TO APPLY SULPHUR WASHES.

The sulphur washes are very destructive to foliage, which limits their use to the late fall or early spring, when the trees are in a dormant state. If the spraying can be done in season, we advise

*A reprint of Circular No. 9, new series.

that treatment with the sulphur wash be made in the spring. The operations should commence early enough to insure the requisite spraying of the trees before the buds burst. The applications of these sprays retain for several weeks considerable insecticidal power which is effective against the progeny of the old scales that chanced to escape destruction by the wash at the time of treatment. For peaches, early spraying, as soon as the ground permits, is recommended. This application will control both scale and peach leaf curl. The sulphur washes, when used in the spring, are very safe sprays; and trees, even when drenched with them or repeatedly sprayed, will usually sustain very little injury.

Applications of the sulphur washes in the fall may cause important injuries to peaches and plums, especially if the wood is unripened. The effects on scale will prove satisfactory. If it is necessary to spray in the fall, the treatment should be made as far as possible to apples and pears, and the hardier sorts of other fruits, as they are less liable to bud injuries. Unfortunately in this State there is very little opportunity in the fall for the satisfactory treatment of apple orchards, because of the late retention of the foliage, which obstructs the sprays, and the early appearance of freezing weather.

In considering the advisability of spraying in the fall, it should be understood that neglected, infested trees will die; and rather than take chances on their treatment in the spring it will pay to spray in the fall, as the increased vigor and usefulness of the trees arising from the control of the scale will more than compensate for probable losses in fruit yields.

OUTFITS FOR COOKING THE WASH.

To prepare the wash satisfactorily it is necessary to have a suitable outfit. In making plans for such an outfit, one should remember that the kind of plant, with reference to the use of a kettle over a fire or the employment of steam to prepare the wash, the location of plant in a position central with respect to the trees to be treated, the water supply, and the number of useful contrivances for handling the water and the wash, have much to do with the ease and cost with which the spray can be made and applied. The following brief description, accompanied by illustrations of the common types of cooking plants will serve as a guide to the erection of an outfit adapted to individual circumstances.

A SATISFACTORY KETTLE OUTFIT.
Cut kindly loaned by the Philadelphia Farmers' Supply Co.

KETTLE OUTFITS.

Small quantities of the lime-sulphur wash may be prepared in one or more large iron kettles or in a feed cooker. This arrangement is not as convenient or as economical as a steam cooking outfit; but it serves very well for the orchardist who does not wish to go to the expense of erecting a more costly plant. With a single kettle of 50 gallons capacity, one can cook 400 to 600 gallons of wash per day or about enough to employ a 100-gallon hand-power spray rig. With a battery of kettles, the amount of wash cooked per day can be increased proportionately.

Boiling the wash in a kettle over an open fire requires close attention to prevent the caking of the lime and the sulphur on the sides of the kettle and to supply the fire with fuel. It is more economical in fuel and labor to have the kettle set in an iron or brick base. There are on the market a number of styles of iron kettles with suitable fire box, as illustrated above, which can be purchased for about ten dollars from local hardware merchants.

STEAM COOKING OUTFIT.

While many fruit growers feel obliged to prepare the sulphur wash in iron kettles, experience has shown that this spray can be cooked more uniformly and cheaply, and with less inconvenience, by the use of steam. These facts are becoming well known among

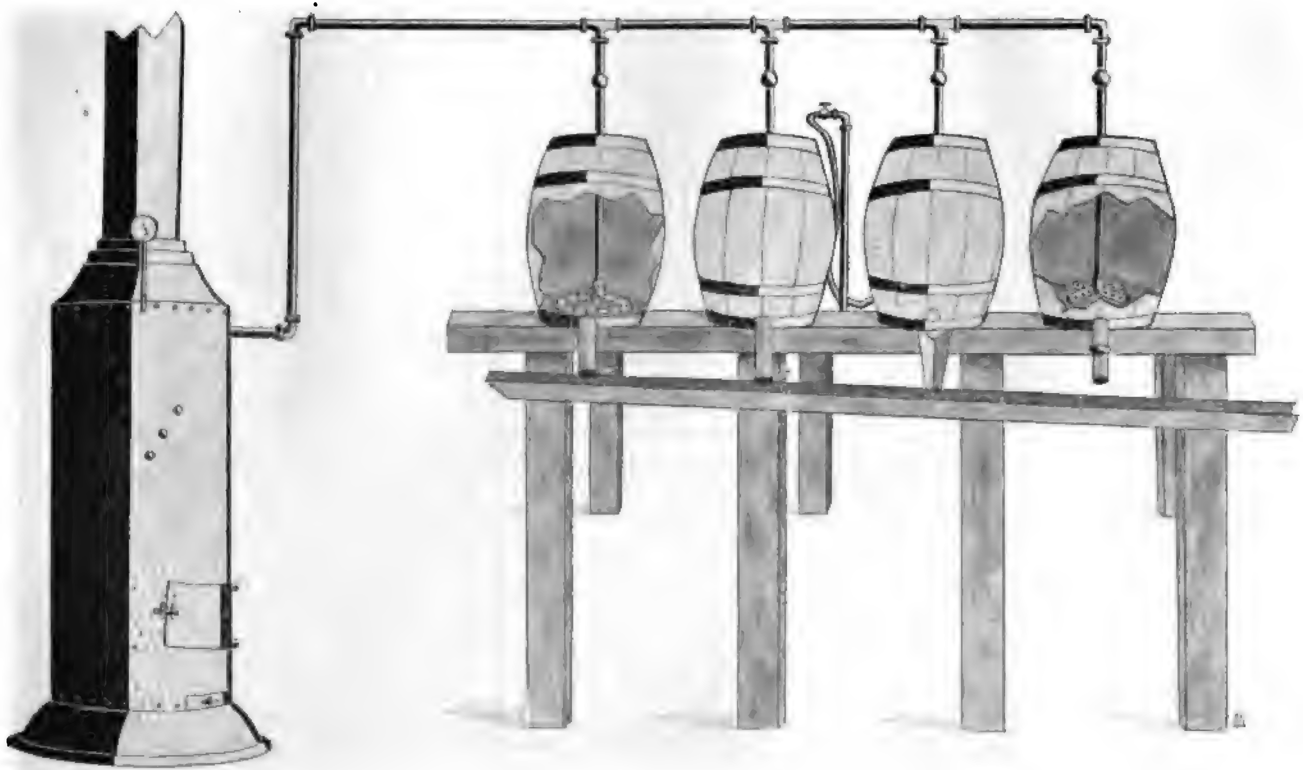

Plate XXXV.—A Plan for a Steam Cooking Outfit.

our fruit growers, who are now erecting steam cooking plants. The outlay for a suitable plant need not be large, and if one possesses mechanical ingenuity a very satisfactory outfit can be provided at moderate expense.

The essentials for a steam cooking plant are a steam boiler with necessary piping, barrels or vats and a plentiful supply of water, located as nearly as possible in the most central point of the orchards to be sprayed. Upright 8-horse-power boilers are commonly used by our fruit growers. Under good management a boiler of this capacity will cook about 2,000 gallons of wash per day or more than enough to keep two power spraying outfits employed. If less wash per day is required, smaller boilers, ranging from 4 to 6 horse power may be used. Fruit growers are warned not to purchase boilers of too small capacity for their needs because of the difficulty of maintaining sufficient steam pressure to cook the wash and to operate as well the injectors to pump water.

For boiling the wash, either barrels or casks are employed. These are usually mounted on platforms about six feet from the ground, so that the prepared wash may flow by gravity from the cooking receptacle to the spraying tank. From an overhead pipe leading from the steam boiler, there are downward extending arms, one leading to each barrel or cask. Each arm is fitted with valves to regulate the inflow of steam. Some fruit growers, to avoid the climbing necessitated by a raised platform, have the boiler and barrels on the same level, and employ injectors to pump water and the engine on the spray rig to convey the wash from the cooking barrel to the wagon tank. While the principles are the same, there is much difference in the appearance, convenience and capacity of the cooking outfits; as the orchardists generally erect the plants to suit their own ingenuity, tastes and circumstances. The illustration in Plate XXXV is an example of an outfit in common use in this State which will assist the fruit grower in erecting a cooking plant to meet his needs and fancy.

SULPHUR WASH CONTROLS OTHER ORCHARD PESTS.

The sulphur wash is a combined insecticide and fungicide. When well applied, this spray not only controls the San José scale, but it is also effective against other orchard pests. Early spraying in the spring will control peach leaf curl; and an application of the wash to apple trees, before the buds burst, will take the place of the first treatment with bordeaux mixture for the prevention of apple scab In some experiments on trees of moderate size treatment with a

sulphur spray has almost entirely prevented injuries by casebearers. The blister-mite on pear trees is largely controlled by applications of this mixture during the dormant season. It is also believed that thorough spraying with the sulphur washes before the buds burst affords considerable relief from the pear psylla. There is no other spray employed that has such a cleansing effect upon fruit trees.

DIPPING OF NURSERY TREES IN SULPHUR WASH.

The dipping of entire trees in a sulphur wash is a dangerous practice and is not advised. The roots of the tree should never come in contact with such a caustic spray. If it is desired to dip, simply immerse the top of the tree in the wash as far as the collar, leaving the roots untreated. For dipping to destroy the scale, sulphur washes are less satisfactory than oil emulsions or miscible oils. In the use of a sulphur wash for the treatment of nursery stock infested with the scale much better results would be obtained by first planting the trees and then spraying them until they are thickly coated.

For shipments of nursery stock the most efficient treatment is fumigation with hydrocyanic acid gas. Detailed directions for its use will be furnished on application.

SOME SUGGESTIONS ON HANDLING THE SULPHUR WASH.

The sulphur wash is very caustic; for this reason one should learn not to expose the bare hands and face to it. Always apply the spray with the wind as the work can be done cheaper and better, and is less disagreeable, since one avoids getting the spray upon himself and the horses. When the wind changes, spray the trees from the other side. For the treatment of large trees, apple especially, use plenty of nozzles, at least four, as the work can be done more quickly and with economy in labor. For the protection of the hands wear the ordinary leather working gloves, into which common lubricating oil has been well rubbed.

THE SELF-BOILED LIME-SULPHUR-CAUSTIC SODA WASH.

Lump lime.	30 lbs.
Sulphur.	15 "
Caustic soda.	6 "
Water.	50 gals.

Place the lime in a barrel and start it to slake with hot water, using enough to prevent the lime from being air-slaked. As soon as the boiling action commences, add sulphur, which has just previ-

ously been made into a paste with hot water. Stir this in thoroughly and pour in water in small quantities to keep the mixture in the form of a rather thin paste. After the slaking of the lime, add the caustic soda and stir till it is dissolved. Cover the barrel with burlap and allow the wash to cook. When the chemical action has ceased, dilute the mixture with water to make the required amount.

This formula is advised for fruit growers who only desire to make small quantities of a sulphur wash, and do not wish to buy a cooking outfit. It is a little more costly than the boiled lime-sulphur wash, and will not, on the whole, prove as uniformly effective as that prepared by external heat. It commends itself to the small fruit growers because it requires no special vessel for its preparation.

Use the same grades of lime and sulphur as for the lime-sulphur wash. For extensive spraying, purchase from wholesale druggists the commercial caustic soda, put up in fifty-pound cans. Upon exposure to the air, the caustic soda absorbs moisture and greatly increases in weight. Odd amounts of the soda may be kept dry in covered Mason jars. To prepare small quantities of the wash one may use any of the common soda lye brands, as sold by grocers.

HOME-MADE OIL-EMULSION.

Crude petroleum or kerosene....................	2 gals.
Whale-oil or fish-oil soap......................	½ lb.
Soft water..	1 gal.

Dissolve the soap, which has been finely divided, in one gallon of boiling water. Remove the vessel from the stove and add the oil. Then agitate the mixture violently for from three to five minutes by pumping into itself, until a creamy mass is formed, from which the oil does not separate. A well-made emulsion will remain stable for a long time, so that the stock supply can be made to be used as occasion requires. Fruit growers are advised not to employ an emulsion which shows a separation of the oil, as applications of such preparations may cause injuries to the trees. Crude petroleum is preferred to kerosene for the spraying of dormant trees in the spring.

OIL EMULSION FOR SPRING USE.

For the spring treatment of apples and pears, before the buds burst, dilute the above formula with seven gallons of water, which makes a spray containing approximately 20 per ct. of crude oil.

If it is desired to make larger quantities of the emulsion, the above proportions should be maintained.

This formula is employed by a number of commercial fruit growers, who have experienced considerable difficulty in controlling the scale in old apple orchards by the use of a sulphur wash. Very satisfactory results have attended its use. With a steam cooking outfit, an emulsion can be more easily prepared than the sulphur wash and it is not so disagreeable to apply. Orchardists whe have been unable to control the scale satisfactorily in the older orchards are advised to try this formula for the entire treatment of the trees or as a spray supplementary to the usual application of the lime-sulphur wash, to reach the scales in the pubescence of the young wood. Successive years' spraying with strong oil emulsions may injure the trees. Orchardists employing these mixtures should watch for the appearance of injury, in which event a safer spray should be used as an alternative treatment.

OIL EMULSION FOR SUMMER USE.

Summer spraying for the scale is now growing in practice. The chief aim of this work is to prevent the spotting of fruit. There are a number of observations which indicate that summer applications by some fruit growers have given fairly satisfactory results and have paid for the trouble and expense, although it is generally believed that the treatment of trees in foliage for the San José scale is usually a failure. Orchardists who have only partially controlled the scale by spring treatments, and who desire to prevent the further breeding and spread of the scale in their orchards are advised to test the value of summer spraying for their own use. For the treatment of trees in full leaf, dilute the above formula with seventeen gallons of water, which makes a spray containing approximately 10 per ct. of oil. In applying the emulsion, pains should be taken to thoroughly wet the fruit, foliage and wood of the branches and limbs which show spotted fruit.

BORDEAUX-KEROSENE-MIXTURE FOR SUMMER USE.

This is a new mixture to be tried experimentally on a few trees to determine its effects upon scale and plant. The merit of this spray is that oil may be used in the ordinary bordeaux mixture, which avoids the necessity of distinct applications of each. The flour acts as a carrier of the oil and in proportion to the amount

used adds to the body of the bordeaux mixture, which permits of a heavy coating of the trees. It should prove of much value for pests like the scale, pear psylla and plant lice.

Kerosene	4 gals.
Wheat flour (cheap grade)	8 lbs.
Bordeaux mixture with the usual poison	36 gals.

Pour the kerosene into a tub or barrel and add the flour. Thoroughly stir or churn the oil and flour by means of a wooden paddle or dasher as employed in upright churns. Now pour in small quantities of the bordeaux mixture, the whole being violently stirred or churned until the spray can be pumped through coarse nozzles. The remainder of the bordeaux mixture may then be added and the combined spray should be pumped through the spraying machine with the usual nozzles attached until the flour is free from lumps and is evenly distributed. The prepared spray, when well made, is smooth, easily atomized and does not clog the nozzles. During spraying operations, the mixture should be continuously agitated to maintain an even distribution of the ingredients. If the spray is allowed to separate into layers, injuries to foliage may follow. This formula contains 10 per ct. of oil. If it is desired to try a higher percentage, use the oil in the proportions of one gallon of oil to at least two pounds of flour. Twice the amount of flour given in the formula may be used, which makes a wash that will heavily coat the trees. The cheapest flour that we have been able to buy at Geneva costs $1.80 per cwt. This wash has proven very satisfactory for summer treatment of the San José scale and apple lice. Orchardists experimenting with this spray are asked to report their results on treating trees in foliage for such pests as scales, plant lice, pear psylla, etc. We are indebted to Prof. W. S. Macoun, of Central Experimental Farm, Ottawa, for the suggestion of the use of flour as a carrier of oil in the bordeaux mixture.

PROPRIETARY MISCIBLE OILS.

These are commercial insecticides and have proprietary names such as Kil-o-Scale, Scalecide, Target-Brand Scale Destroyer, etc. The important ingredients in the more efficient of these preparations are oils which have been combined with some emulsifying agent to facilitate a uniform dilution with water. The cost of the miscible oils is from 50 cents to $1.25 a gallon, depending on the quantity purchased. While more costly, they are the most convenient of scale remedies to prepare for use, as all that is demanded

is to dilute the oil with water in the required proportions. These mixtures are well adapted to the needs of individuals who have only a few trees or small orchards to spray. Throughout the State there are fruit growers who, because of the ease of preparation, prefer these oils to other remedies. In the Station experience these preparations should be used in stronger proportions than is commonly recommended. If only one application is made, spray in the spring as the buds are swelling, using one part of the oil diluted with ten or fifteen parts of water. *The miscible oils should never be applied while the trees are in leaf or when the buds are opening as the applications may cause severe injuries.*

It is claimed that these preparations may be safely used in the fall as soon as the majority of leaves have fallen, and that even more satisfactory results may be obtained on scale than by spring applications. The Station experiments have not given conclusive results on the safeness of such practice, so that the fruit grower planning for fall spraying should keep this point in mind. Kil-o-Scale may be purchased from Griffith & Turner, Baltimore, Md.; Scalecide from the B. G. Pratt Company, 11 Broadway, New York City; and Target Brand Scale Destroyer from the American Horticultural Distributing Co., Martinsburg, W. Va. These preparations may also often be purchased from local dealers in spraying supplies.

HOME-MADE MISCIBLE OILS.

These are new sprays and their use is largely tentative, to determine their utility under ordinary orchard conditions. These mixtures require much more care and exactness in their preparation than the common scale remedies, and the chemical trade is not generally well informed of the supplies required by the present formula. For these reasons we advise fruit growers that home-made miscible oils are largely experimental remedies and should not be extensively used until the ability of the average orchardist to prepare them or have them compounded properly has been satisfactorily determined. Publications on the preparation of miscible oils are bulletins 75 and 79, Delaware Experimental Station, Newark, Del., and bulletin 49 Storrs Experiment Station, Storrs, Conn.

THINNING OUT AND PRUNING OF OLD APPLE ORCHARDS.

Close planting of orchards was formerly a common practice and as a result many apple trees have become very crowded. The trees have produced too much top growth, which is difficult to spray, and

have too little bearing surface below, to make the treatment practicable. It is not an infrequent occurrence that the lower limbs thickly interlace, and for want of sufficient light yield only mediocre fruit. To spray an orchard in this condition satisfactorily is almost impossible and is generally unprofitable. Such an orchard should be carefully thinned out by removal of some of the trees, pruned, and well cared for in other respects, to facilitate spraying operations and to promote a more symmetrical growth and greater fruitfulness. In many communities there are old apple orchards which have been rejuvenated by these means and which serve as models for such work.

In Niagara County, the topmost branches are often "headed in" from four to ten feet to a good lateral, to reduce the height of the trees, and thus permit of more thorough applications of the spraying mixtures. When the pruning and treatment of wounds have been carefully done, the results have been satisfactory. But much harm has been done by indiscriminate slashing of the trees and by neglect to paint wounded surfaces. Disease and decay have invariably destroyed the tips of the stubbed branches and have weakened the principal lateral, which is oftentimes killed or broken off by the wind. If the scale is being satisfactorily held in check, the orchardist should avoid "heading in" because of the loss of bearing surface and the danger of diseases becoming established in the wounds.

REPORT

OF THE

Horticultural Department.

U. P. Hedrick, *Horticulturist.*

N. O. Booth,* *Assistant Horticulturist.*

Richard Wellington, *Assistant Horticulturist.*

Maxwell J. Dorsey, *Assistant Horticulturist.*

Wm. H. Alderman,† *Assistant Horticulturist.*

O. M. Taylor, *Foreman.*

TABLE OF CONTENTS.

Distribution of Station strawberries and raspberries.
The relation of weather to the setting of fruit.
Varieties of strawberries, and cultural directions.

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* Resigned November 15, 1908.
† Appointed August 13, 1908.

REPORT OF THE HORTICULTURAL DEPARTMENT.

DISTRIBUTION OF STATION STRAWBERRIES AND RASPBERRIES.*

U. P. HEDRICK AND O. M. TAYLOR.

INTRODUCTION.

The New York Agricultural Experiment Station has four new varieties of red raspberries and three new varieties of strawberries for distribution during the spring of 1908. These varieties are the incidental outcome of experimental work in plant breeding. They have been grown and compared with practically all of the standard sorts and novelties of their kind and are equal to or superior to all other red raspberries and strawberries grown on the Station grounds in one or more respects. The distribution of these varieties is undertaken that we may ascertain their value and adaptability in the different fruit regions of New York. We hope, too, by sending out these plants, and through the account of their origin herewith given, to stimulate the interest of fruit-growers in plant breeding and to promote local experimentation with varieties of fruit.

The breeding of fruits and vegetables is becoming the most prominent feature of the work of the Horticultural Department of this Station. Since the objects and methods of plant breeding are not well understood by fruit-growers, or the public, a few explanatory statements regarding such work in horticulture at this Station are in place.

For a quarter of a century this Station has been attempting the improvement of horticultural plants. Several new vegetables and

*A reprint of Bulletin No. 298.

at least one meritorious fruit, the Hunn strawberry, have been given to horticulture. In the beginning the chief aim was to originate new varieties; but more and more, as the work has been carried forward, new varieties have become incidental and now plant breeding for itself is given chief attention. This Department is now attempting, and has made some progress, in breeding all of the tree fruits, grapes, red raspberries, strawberries and several of the vegetables. Roughly grouped, the objects in carrying on this work are, at the present time:

(1) A study in the correlations of the different characters of plants. Professor S. A. Beach, formerly in charge of the work, has made several contributions to the knowledge of this subject from work done on the Station grounds.[1]

(2) Investigations of the laws of inheritance and variability. A paper on this phase of plant breeding containing a record of the behavior of crossed tomatoes was presented by the writer and Mr. N. O. Booth at the fifth annual meeting of the Society of Horticultural Science.[2]

(3) The adaptation of plants to new environment. To this end the Station is now testing about 1760 varieties of American and foreign fruits.

(4) The development of hardy plants. The peach is the special object of study in this case. Considerable preliminary work has been done in the study of the factors which influence hardiness of the peach.[3] A plantation of all obtainable varieties, 258 sorts, has been set for experimental and breeding purposes, with special reference to hardiness.

(5) The development of resistance to disease. Illustrative of this work two examples may be cited. Several hundred seedling pears are now being grown from parents more or less immune to pear blight, with the possibility of getting a variety comparatively immune to this disease. All obtainable varieties of head lettuce have been grown and selections and crosses made in the hope of getting a variety that will withstand " lettuce rot " and " tip-burn."

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[1] Grape Breeding: Size, Weight and Specific Gravity of the Seed as correlated with Germination and Vigor of the Seedling. Proceedings of the Society for Horticultural Science, 1: 42.

[2] Mendelian Characters in Tomatoes. Proceedings of the Society for Horticultural Science, 1907. (In press.)

[3] U. P. Hedrick: Factors Affecting Hardiness of the Peach. International Conference on Plant Breeding, New York, 1907, p. 19.

(6) Improvement through crossing and hybridizing as a basis for generalizations as to the use of these operations in plant breeding. There are now growing about 2700 crosses and hybrids on the Station grounds and many times as many more have been discarded in the past few years.

(7) Systematic selection from pure-bred seedlings. A considerable number of pure-bred grapes have been and are now being grown for this purpose.

(8) To discover what botanical and horticultural groups of the several fruits and vegetables best transmit their characters to their offspring either as pure-breds or in crosses. Valuable data as to the transmitting power of groups of grapes, apples, raspberries and strawberries have already accumulated.

(9) Incidental to the above lines of research, the production of new varieties. Seven of these are described in this Bulletin.

One or two words further are necessary to a proper understanding of this work by the layman. In all of the plant breeding in this Station an attempt is made to study every plant and to make a more or less full record of its behavior, whether promising or not from the grower's standpoint. With each group of plants the work is along well defined lines, for a definite object, and according to a specific method. The desire is to know exactly how any particular result is attained. No time limit is set to any of the problems in plant breeding and it is not the intention to publish results nor distribute new varieties at stated times. The Station is not a competitor of seedsmen or nurserymen, and does not distribute seeds or plants that can be obtained in the trade. It should be said, too, that the Stations is anxious that the trade have and offer for sale any of the new varieties that may be produced in the breeding work of this institution. It desires, too, that seedsmen and nurserymen have a full knowledge of the work done in breeding plants that they may take advantage of any progress made by the Station in this field.

STATION STRAWBERRIES.

The breeding work which gave rise to the three varieties of strawberries now to be distributed was begun in 1898. During this season seeds were saved from three crosses and self pollinated seed was saved from one variety. In making the crosses, and in saving.

keeping and sowing the seed the usual precautions were taken with the result that plants as follows were grown in 1899:

Hunn X Marshall	255	plants.
Sample X Marshall	31	"
Hunn X Atlantic	197	"
Marshall, pure bred	61	"
Total	544	"

The crosses were made by Wendell Paddock, then of this Department, and the subsequent work of selection has been done, in the main, by O. M. Taylor, Foreman in Horticulture. The division of labor with these particular varieties serves as a reminder of the divided work in practically all plant breeding. First, there must be a starting point and, whether of parents to cross or an individual to breed from, good judgment must be exercised in selecting plants with the characters desired most highly developed and so far as known with characters most transmissible. Second, skill must be patiently and persistently exercised in selecting the plants most nearly approaching the ideal in mind until the end sought for is as nearly as possible attained; perfection is scarcely possible.

The history of the 544 plants obtained in 1899 is quickly given. Most of them fruited in 1900 and it was apparent at once that at least three-fourths of them were worthless and these were forthwith discarded. The plants weeded out either produced inferior berries, lacked vigor, or showed one or more markedly poor characters. After a further selection and weeding out in 1901, 31 seedlings remained and these were allowed to form runners which were removed to new beds in 1902. In the summer of 1903, the 31 seedlings fruited and all but three were discarded. After five years and three crops of fruit the number was reduced from 544 to 3 seedlings. The years following have been devoted to further testing the three remaining seedlings and now, after ten years of selection and testing, these have become named varieties. For fear the length of time taken in the breeding of these strawberries may discourage the prospective plant breeder, it should be said that at the end of the fifth or of the sixth year at most, the value of the three seedlings which we have named was known and the work of producing the new varieties was completed.

The crosses have given varieties as follows:

Hunn X Marshall	255 plants,	1 variety
Hunn X Atlantic	197 "	1 "
Sample X Marshall	31 "	1 "
Marshall, pure bred	61 "	0 "

The above results are interesting but scarcely even suggestive. The figures are not nearly great enough to draw conclusions as to the transmitting power of the four parents. About the only generalizations that can be made in regard to these crosses are that in the offspring of those in which Marshall was one of the parents the foliage of this variety appeared in the great majority of the seedlings. So, too, the fruit characters of Hunn were dominant in the resulting seedlings over those of Marshall and Atlantic with which it was crossed.

The following is a description of these seedlings:

Magnus.— Parentage, Hunn X Marshall. Blossoms imperfect. Plants numerous, medium to above in height, productive. Leaves large, attractive dark green, attacked slightly by leaf blight in unfavorable seasons; leaf stems medium in length, thick. Fruit stems of average length, thick, and usually double. Calyx large and leafy, set in a slight depression. Seeds raised. Fruit above medium to very large, retains its size well as the season advances, roundish conic to slightly elongated and with pointed apex, very dark scarlet, showing Hunn blood, variable in color unless well ripened. Flesh, rather light at center, firm, juicy, mildly acid, good to very good in flavor and quality. The fruit ripens in mid-season. The growth and color of foliage closely resemble Marshall, while the color of the fruit is that of the Hunn. When well colored, this variety ranks among the very best in size, attractiveness, and quality. It is thought that the Magnus will prove a very valuable new sort for home use. Its variable color is somewhat against it as a berry for the market.

Prolific.— Parentage, Sample X Marshall. Blossoms perfect. Plants very numerous, vigorous to very vigorous, usually productive, yielding on the Station grounds as high as 14,052 quarts per acre. Foliage of good size, somewhat susceptible to leaf blight in unfavorable seasons, in color comparatively dark green; leaf stems long, thick. Fruit stems of medium length, stout and usually single. Calyx medium to below in size, depressed, sometimes slightly discolored. Seeds somewhat raised. Fruit very large to

above medium, roundish conic to blunt wedge, rather light in color but nevertheless an attractive bright scarlet. Flesh firm, fairly good color at center, agreeably acid and of good flavor and quality. Fruit ripens in early mid-season. The color of fruit is slightly lighter than Marshall, possibly a merit for some markets. On account of its vigor, the great productiveness of its plants, and the attractiveness of the large well-colored berries, this variety gives promise of taking front rank among standard commercial strawberries.

Quality.— Parentage, Hunn X Atlantic. Blossoms variable, averaging semi-perfect. Plants somewhat numerous, fairly productive, healthy, and of average vigor. Leaves medium to above in size, moderately dark green; leaf stems medium to below in length, rather stout. Fruit stems short, stout, usually double. Calyx medium to large, leafy, set in a slight depression. Seeds sunken. Fruit above medium to very large, roundish conic to wedge, or varying to slightly elongated but blunt at apex, light and dark scarlet, glossy. Flesh good color to center of fruit, firm, mildly acid, good to very good in flavor and quality. Season rather late. Both plant and berry of the Quality resemble the Hunn more than the Atlantic.

A characteristic of the Quality is its great variability in sex. On the Station grounds it ranges through all gradations from perfect to imperfect.

Although lacking somewhat in productiveness, Quality ranks high in general appearance and in quality, and if these characteristics show in other localities, the variety is well worthy of a place in the home plantation and many possibly prove a good commercial sort.

STATION RASPBERRIES.

The work in breeding raspberries dates back to 1897 and 1898 when seeds from six crosses and self pollinated seeds from three varieties were saved. As with the strawberries, the crosses were made by Mr. Paddock and the subsequent work of selection has been done by Mr. Taylor. The parentage and numbers of resulting seedlings are as follows:

Loudon X Marlboro	372	plants.
Marlboro X Loudon	204	"
Superlative X Marlboro	273	"
Marlboro X Superlative	195	"

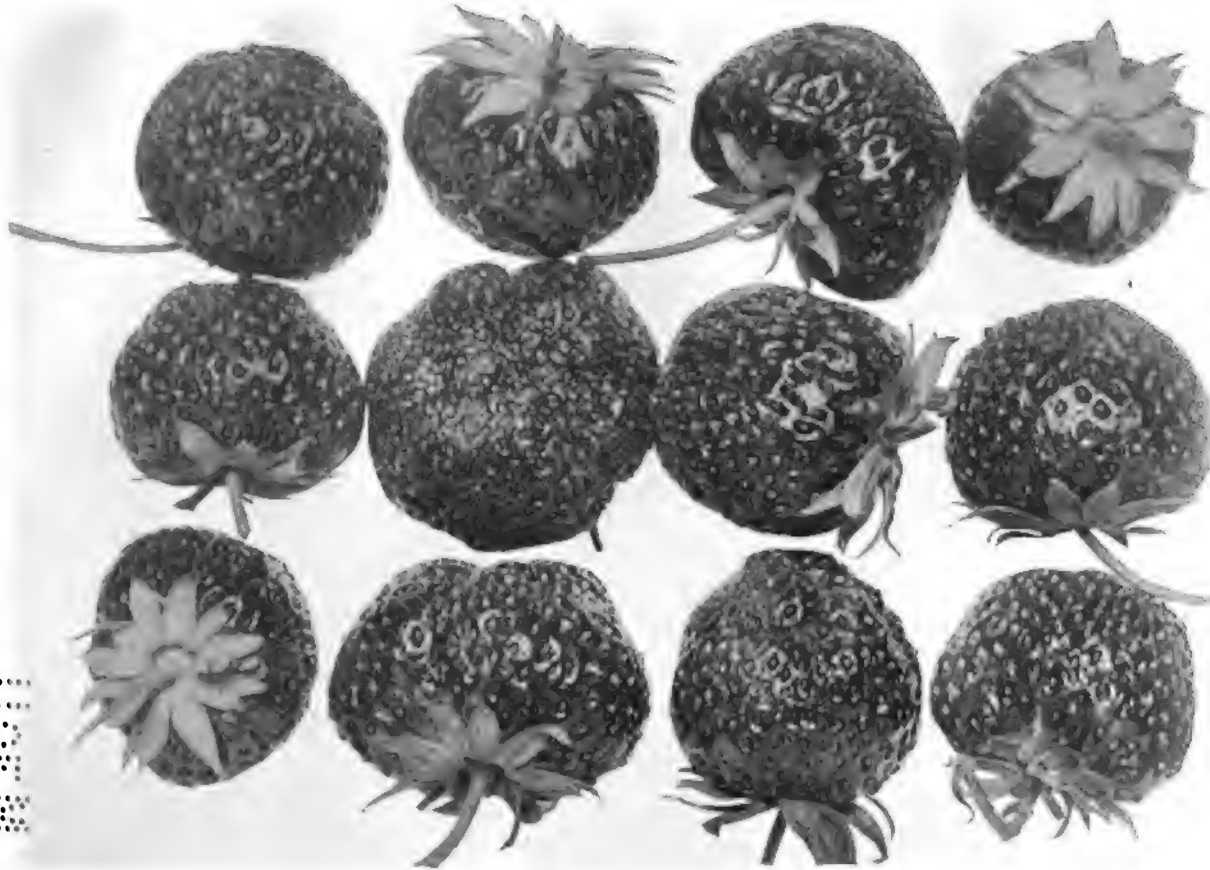

PLATE XXXVI — MAGNUS.
(Actual size.)

PLATE XXXVII — PROLIFIC.
(Actual size.)

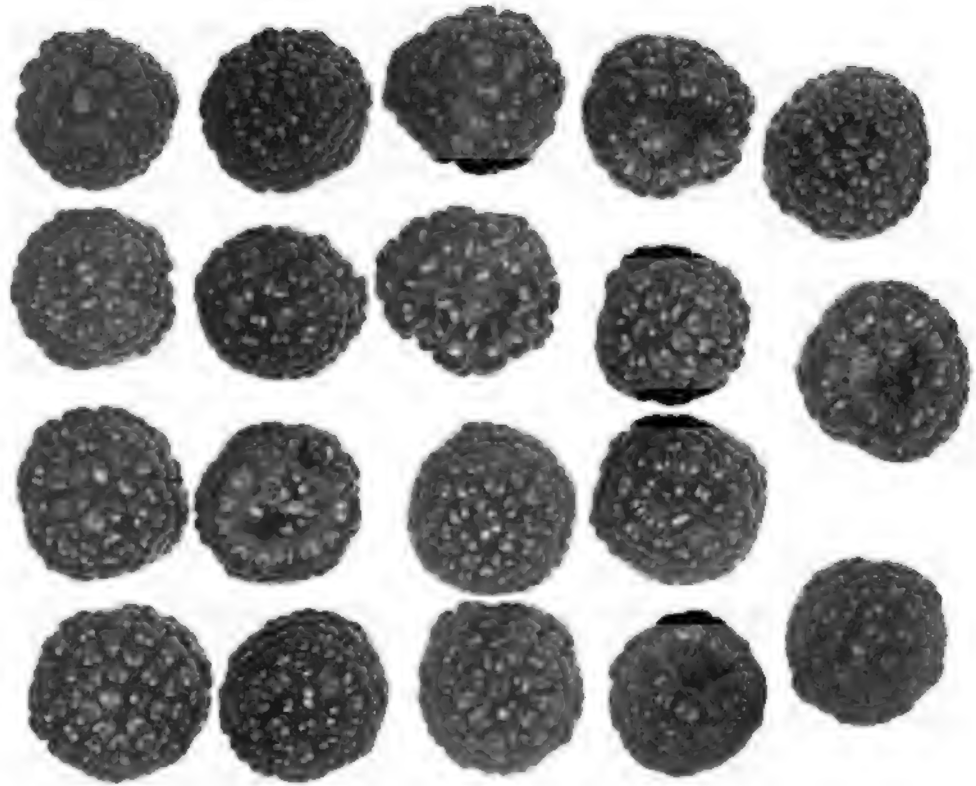

Plate XXXVIII — Marlative.
(Actual size.)

MARLATIVE. PLATE XXXIX. LOUBORO.

Loudon X Superlative	35	plants
Superlative X Loudon	60	"
Marlboro pure	32	"
Shaffer pure	17	"
Caroline pure	3	"
Total	1191	plants

The history of these 1191 seedlings is similar to that of the strawberries in the matter of length of time the majority of them were permitted to live. At the close of the first fruiting season all but 44 were destroyed. In the years that have followed further selections have reduced the number to eight, all offsprings of the crosses, no variety worth perpetuating having come from the pure bred seedlings. In six of the eight varieties the parents have been Loudon and Marlboro, five from Loudon X Marlboro and one from Marlboro X Loudon. In the other two the parents were, of one, Marlboro X Superlative and of the other, Superlative X Marlboro. Four of the seedlings have been named and are herewith offered for further testing in the State. Three of the remaining seedlings are still on the doubtful list, and the fourth, probably the most valuable of the eight seedlings because of its extreme earliness, will not be ready for distribution until the spring of 1909.

The following is a description of the four seedlings now ready for distribution:

Louboro.— Parentage, Loudon X Marlboro. A comparatively strong grower, intermediate in height and vigor between its parents. The canes are numerous and more closely resemble Loudon than Marlboro in general appearance. The berries average fully as large or slightly larger than either parent and retain their size well as the season advances; the fruits vary somewhat in firmness and color but are fairly firm and in general are a handsome light red; in flavor and quality, good. The berry closely resembles Marlboro in shape and in drupelets. The season is slightly earlier than Loudon. The Louboro has proved hardy except in severe winters and is very productive, yielding over 9,000 quarts per acre on the Station grounds.

While this variety may possibly prove too light in color, and not firm enough in wet seasons, yet it appears to be very worthy of an extended trial as a commercial sort, on account of its extreme productiveness and the large size of the fruit.

Marldon.— Parentage, Marlboro X Loudon. The canes of this variety are lighter in color than those of either parent and in general are of the Marlboro type, though more vigorous and stockier. Suckers appear in great numbers and grow rapidly into hardy and productive canes yielding as high as 10,257 quarts per acre in the Station plantation.

The fruit is large to very large and retains its size well as the season advances, slightly longer than Marlboro, handsome dark red in color, and of average firmness, earlier than either parent. Although not as sweet nor as highly flavored as the best standard varieties, it ranks better than the average and on account of its hardiness, vigor, productiveness, large size and the handsome color of the fruit, it is worthy of trial as a commercial sort.

Donboro.— Parentage, Loudon X Marlboro. The numerous canes are intermediate in general appearance between the parents, though stockier and stronger than either parent, nearly smooth. The plants have proved hardy, except in the most severe winters, and are very productive, yielding in one season 10,964 quarts per acre. The foliage is a very attractive dark green. The fruit is large to very large and holds up well in size as the season advances; it is an attractive light red in color and very firm. The Donboro resembles Marlboro in shape and color, and is fully equal to this parent in flavor and quality.

This variety has made a high record at the Station as a commercial sort and is worthy of a careful test as a market berry.

Marlative.— Parentage, Marlboro X Superlative. Growth very stocky, semi-dwarf, growing slightly taller than the Superlative, very productive, yielding as high as 11,720 quarts per acre, as grown at the Station. The berries ripen earlier than Loudon. In general appearance the canes resemble Marlboro. The fruit is unusually large, dark red, more attractive than either parent, firm, and good in flavor and quality. The drupelets are very large and somewhat coarse in appearance, so much so that the surface of the berry is uneven. Although Marlative has not proved hardy every season and has shown a strong tendency to crumble some seasons, yet, on account of its unusual attractiveness in size and color, it is worthy of testing as a fancy sort for commercial purposes. Possibly on other soils the tendency to crumble may disappear.

TERMS OF DISTRIBUTION.

There are no restrictions upon recipients of plants as to further distribution of the varieties by sale or otherwise. If the fruits prove meritorious, it is desired that they be generally disseminated as quickly as possible. The only obligations asked of those who receive plants are that they keep the varieties true to name, give them good care, and that they report to the Station the behavior of the varieties. The Station will furnish blanks for reports. Reports will be asked for, not only once, but from time to time until the value of a variety for a locality is determined. Applicants should state that they will comply with the above conditions.

The plants are furnished to accepted applicants and are packed without charge but the recipient must pay the expressage. Plants will not be sent by mail. Applicants must give both mail and express addresses.

The Station can supply but comparatively few growers of small fruits of the State with the new varieties and reserves the right to make a choice of the growers to whom they will be sent as may be preferred. This choice will depend chiefly on priority of application and upon the number of applicants from a locality. We cannot furnish any of these varieties to citizens of other states.

The number of plants of each variety that can be furnished to one person is 6 for the raspberries and 12 for the strawberries. It is desired that a person receiving any should receive all of the varieties of each or both fruits that a comparative test may be made of them.

An applicant should state whether or not he is growing either or both of the fruits in a commercial way as it is not the wish to send the new sorts to those who are not growing standard kinds with which they may be compared.

Since there are comparatively few plants for general distribution, those who want them for home use only, or to grow them out of curiosity, or because they can be had for nothing, are asked not to apply.

This Station does not invite application for plants, scions or seeds other than those specifically offered through its publications. Generally we cannot furnish them.

Address all correspondence regarding these new fruits to Horticultural Department, New York Agricultural Experiment Station, Geneva, N. Y.

THE RELATION OF WEATHER TO THE SETTING OF FRUIT; WITH BLOOMING DATA FOR 866 VARIETIFS OF FRUIT.*

U. P. HEDRICK.

SUMMARY.

1. The relations of weather to the formation and development of fruit seem to have been lost sight of in the current discussions of the failures of blossoms to set fruit.

2. In New York, unfavorable weather is probably the predominating one of the several factors which cause the loss of fruit crops during blooming time.

3. Late frosts ruined the fruit crop in western New York in 1889, 1890, 1895, and 1902. The fruit crops of 1884, 1888, 1891, 1893, and 1903 were seriously damaged by killing frosts. Besides the above years, pears, peaches and plums were more or less injured by frosts in 1892, 1896, and 1900. Fruits were injured at blossoming time by frosts in thirteen years out of the twenty-five under consideration.

The average date at which the last killing frost is likely to occur in any locality, as a normal event, must often determine the limit in latitude or altitude at which a fruit can be grown. Even in the most favored fruit regions of the state the records bring out the fact that killing frosts must be expected, occasionally, to destroy the fruit crop wholly or in part.

4. Wet weather almost wholly prevented the setting of fruit in New York in the years 1881, 1882, 1883, 1886, 1890, 1892 and 1901. Rain is mentioned as one of the causes of a poor setting of fruit in the years 1888, 1889, 1891, 1893, 1894, 1898, 1905. Of the seasons given above, moisture came at blossoming time in the form of snow in 1899 and in 1891. Gales of wind accompanied the rain in 1881, 1882, 1883, and 1905. The rainfall came in periods of prolonged cold weather in the years 1881, 1882,

* A reprint of Bulletin No. 299.

1883, 1886, 1888, 1889, 1891, 1892, 1894, 1898, 1905. In 1890 the rainy weather was hot and sultry. Frosts and cold weather accompanied the rains in 1888, 1889, 1890, 1891, and 1892.

Rain and the cold and wind that usually accompany it at blossoming time cause the loss of more fruit than any other climatal agencies. The damage is done in several ways. The most obvious injury is the washing of the pollen from the anthers. The secretion on the stigmas also is often washed away or becomes so diluted that the pollen does not germinate. It is probable that the chill of rainy weather decreases the vitality of the pollen and an excess of moisture often causes pollen grains to swell and burst. Rain also prevents bees and insects from carrying pollen.

5. A temperature low enough to be harmful to blossoms is usually associated with frost or rain; but a low temperature, even though it does not touch the frost point, nor accompany rain, is often disastrous to the setting of fruit. The injurious effect is probably due to the prevention of the growth of the pollen-tubes.

The average daily range in temperature is an important constituent of blooming time weather. When the daily range is highest the danger to blossoms is greatest. The most jeopardizing weather to the fruit crop, from the standpoint of temperature, consists of warm, sunny days followed by still, cloudless, cold nights. The danger is all the greater in such stresses of weather because the heat of the day forces out the blossoms prematurely.

6. Sunny weather is reported at blooming-time in western New York in the years 1885, 1887, 1896, 1897 and 1900. In each of the above years the sunshine was accompanied by warm, dry weather. It is a most significant fact that there were good crops of fruit in all of the years named and that in three of them there were record-breaking crops of one or another of the fruits and enormous crops of practically all of the tree-fruits.

7. Wind of sufficient strength to damage blossoms in New York occurred in the years 1881, 1882, 1883, and 1895. In the years when rainfall was detrimental to blossoms, wind is mentioned several times as an accompaniment. Wind is not mentioned in any of the years of frostiness.

The effects of wind may be summarized as follows: Winds whip blossoms from the trees and prevent insects from working. Long continued, warm, dry winds injure blossoms by evaporating the secretion from the stigmas, thereby preventing the retention and germination of pollen. Damp, warm winds, if long con-

tinued, are unfavorable to pollination. A cold, dry, north wind in blooming-time chills vegetation and stops the normal functions of flowers and leaves. On cold, clear nights, winds keep off frosts by renewing the heat; or by bringing fogs or clouds from lakes or ocean, frosts are prevented on the leeward side of the water.

8. It is beyond the power of man to control weather except in the case of light frosts which may be prevented to some extent by whitewashing trees to delay blooming-time; by smudging to prevent loss of heat by radiation; and by the use of numerous fires in the orchard to raise the temperature.

9. Locations for growing the different fruits should be selected with reference to general and local climate; in the first case, latitude, altitude and proximity to large bodies of water are the determining factors; in the second case the lay of the land is the determinant.

10. Varieties of fruit of the several kinds can be selected with reference to time of blossoming to escape in some degree injurious stresses of weather.

11. Fruits may be selected with reference to their ability, from one cause or another, to withstand injurious weather; of the several factors which influence hardiness, cultural treatment to induce strong vitality probably helps plants most to withstand stresses of harmful weather.

12. The climate changes in short cycles but such oscillations are not permanent and it is probably beyond the power of man to change the climate by flooding or draining, by planting or destroying forests, or by any other means.

13. Ths time of blooming is a particularly important period in growing fruits and especially so as to the welfare of the crop. The dates of blooming for 866 varieties of fruit are given in the bulletin and from these the following deductions may be drawn:

14. If cross-fertilization is to play an important part in fruit-growing, in planting to secure it kinds must be chosen which come into blossom at the same time as those which they are expected to fertilize. A table is given which shows the sorts that bloom together or nearly enough so to make cross-pollination possible. It will be found upon examining the list, that under normal conditions and during the average season, varieties of any one species overlap sufficiently for the above purpose unless it be the very early and the very late varieties.

15. It is believed by some that early varieties bloom earlier than late ones and that late varieties are therefore less liable to have their blossoms injured by late frosts. By selecting a large number of any of the several fruits for which blooming dates are given and by making a list from the fruit manuals of their period of ripening it is found that there is absolutely no correlation between blooming and fruiting, although there are many apparent exceptions.

16. The averages of the data for the five years considered in this bulletin show the length of time the several fruits are in bloom: For apples as a species it is about 9 days; pears, 7 days; peaches, 8 days; plums, 7 days; cherries, 7 days; grapes, 10 days. The time from first blossoms until all have dropped varies in accordance with the factors we have discussed as affecting blooming time. In very hot, dry weather blossoms of some fruits do not last longer than forty-eight hours.

17. An inspection of the dates of blooming of all the fruits shows that there is a variation of several days in most seasons between the appearance of the first blossoms of the different varieties. This can be taken advantage of in selecting sorts to avoid injury from frost.

18. It is probable that early blooming varieties are not nearly so well cross-pollinated as the late blooming sorts; for there are always many blossoms on the early blooming sorts appearing late and until the late blooming kinds are in full bloom; and it is likely that pollen carried by insects maintains its viability for a considerable length of time making it available for the cross-pollination of the late blooming varieties.

INTRODUCTION.

In the current discussions of the failure of blossoms to set fruit we seem to have lost sight of the relations of weather to fruit formation and development. The uncertainties at this period in the growth of orchard crops, in recent years, have been attributed almost entirely to the lack of cross-pollination. It is probable that the latter factor is an important one with some fruits. It has been so proved by a number of careful experimenters, and the experience of fruit-growers confirms it as a fact and attests to its importance. Yet there are many orchardists in this State who, having tried mixed planting of tree-fruits, apples

and pears in particular, to secure cross pollination and without resulting crops of fruit, doubt the value of such plantings, holding that the disadvantages of mixed planting outweigh the advantages. A prominent German experimenter,[1] after several years of investigation, denies that there is any gain in the setting of fruit in mixed plantations of apples and pears. There is therefore a controversy as to the necessity of cross-pollination for the setting of apples and pears and this shows that there is need of further investigation to determine with greater certainty why orchard trees so often fail to set fruit when there is an abundance of blossoms.

Admitting that self-sterility with a lack of cross-pollination is a cause of failure of many plants to set fruit, all agree that there are other causes; as, weather; age and vigor of plant; the individuality of the plant; and plant environment whereby food, moisture, light and other conditions are affected.

One cannot read the records of fruit growing in New York without concluding that among these, unfavorable weather is the predominating factor in the loss of fruit crops during blossoming time; in fact that weather exerts a controlling influence far more powerful than all other causes. Unfortunately there seems to have been but little investigation to show the relations of weather to the setting of fruit; and because the deleterious effects of unfavorable weather have not been more carefully set before the fruit-grower, and because of the impossibility of controlling weather conditions, the important relationships of weather to the setting of fruit are largely overlooked in orchard practice.

The fact that weather cannot be controlled is not sufficient reason for this neglect. Inquiries as to the nature and influence of atmospheric agencies at blooming-time should be helpful in many ways: In determining causes of failure; in selecting sites for orchards; through a study of the relation of weather to the setting of fruit for a past period we shall be able to forecast the future with more assurance; and through more accurate knowledge of the weather and its relationship to the setting of fruit the orchardist can better prevent the evil effects of bad weather.

There is much to lead us to believe, too, that the stresses of weather, of cold and heat, of wetness and dryness — which we have in eastern and central United States, largely account for

[1] Ewert. Blutenbiologie und Tragbarkeit unserer Obstbäume. *Landw. Jahrb.*, 35: 258–287, pls. 2. 1906.

the comparative sterility in many varieties of our fruits. On the Pacific coast, where the weather is much more equable, varieties of apples, pears and plums which are rated as sterile in New York are fertile, or more nearly so than in the East. The same is true with varieties of fruits in England as compared with the same kinds in eastern United States. Varieties of strawberries having imperfect flowers in our climate, under the more equable climate of California or England, produce perfect flowers.

The subject in hand can be investigated by direct experimentation with weather and plants; or, by inferences drawn from the behavior of fruit crops during the varying weather conditions of past seasons. The first method is probably the more accurate, but since weather does not come to one's making, and cannot be varied at will, nor applied locally, it would require much time to investigate the subject experimentally. The second method, while lacking in accuracy, is more suggestive; is available at once; covers a larger field; and for preliminary work need not be less useful than direct experimentation. In this investigation we have relied on the second method almost entirely.

What is *weather?* Not simply the vicissitudes of the season, the stresses of weather, the sense in which the term is so often taken. It is used here in the sense of meaning all of the common phenomena of the atmosphere; as, heat or cold, wetness or dryness, clearness or cloudiness, calm or wind. An extremity of any one of these attributes of weather may endanger the fruit crop at blossoming time.

So, too, we need to define the other term of our subject. The *setting* of fruit comprises the several processes which take place in the blossom in the formation of fruit. The layman needs to study well the delicate and complicated procession of events which take place in a blossom during the formation of a fruit in order to appreciate how easily it may be jeopardized by unfavorable external or internal influences. With most plants the young fruits begin to form before fertilization takes place, though the unfertilized ovaries have but a slight hold upon life. Any untoward influence, even the least, may cause the fruit to drop. Fertilization seems to give the tiny fruits new life and to strengthen the attachment to the parent plant, probably because of the nourishment drawn to supply the embryo. Thus this life event usually — not always — determines whether a fruit is to hang or to drop, though it in no way insures its complete development. Even after fertilization, successful so far as can be determined, much fruit drops.

In this investigation of the relationships of weather and fruit setting we are fortunate in having the printed records of the fruit crop of a great horticultural region for the past twenty-five years. The records appear in the Proceedings of the Western New York Horticultural Society under the head of "Reports of the County Committees." These reports chronicle various facts of interest and value regarding the fruit crop for the year and county for which they were written. They are signed for most part by the chairmen of the committee, but the names of those who assisted in securing the facts set forth are to be found in the printed lists of committees. Among those who have served on these committees are the names of some of the most noted American horticulturists; as, Patrick Barry, George Ellwanger, H. E. Hooker, James Vick, J. S. Woodward, S. D. Willard, T. S. Hubbard, E. A. Long, W. R. Lazenby, E. Moody, L. Yeomans, C. M. Hooker, W. C. Barry, George S. Josselyn, Prof. I. P. Roberts, Jno. W. Spencer, L. H. Bailey, and many others, possibly less well known, but scarcely less competent for the work. The accuracy and judgment of such men cannot be doubted. Moreover, the reports, beside appearing over the names of these selected men, have been under the fire of the criticism of an able and critical horticultural society. Examination of crop reports, weather records and the agricultural papers for the period under discussion, were made to further strengthen the data given, so that, coming from all these sources we believe them to be reliable.

WEATHER AND FRUIT-SETTING FOR THE YEAR 1881 TO 1905 INCLUSIVE.

Ninety-seven reports have been considered out of the several hundred covering the twenty-five years included in this investigation; the reports are from sixteen counties and they were presented by thirty-five men acting as chairmen of the county committees; in several counties the same committee acted year after year, giving thereby greater accuracy and uniformity to the data. It is impossible to classify these reports to show conclusively the relative importance of the several weather constituents in causing the failures of fruits to set; or to show what localities are most advantageously located with respect to weather. But the rough classification attempted should suggest what weather factors most injure fruit, and the tables which accompany this summary should

show what localities are best favored with weather suitable for fruit-setting. It is thought best to add such facts in the discussion, gleaned from whatever source, as would be helpful to the fruit grower in combatting unfavorable weather.

KILLING FROSTS AND FRUIT-SETTING.

Late frosts ruined the fruit crop in western New York in 1889, 1890, 1895 and 1902.

The fruit crops of 1884, 1888, 1891, 1893 and 1903 were seriously damaged by killing frosts.

Besides the above years, pears, peaches and plums were more or less injured by frosts in 1892, 1896 and 1900.

Thus, considerable damage was done to fruits at blossoming-time by frosts in thirteen years out of the twenty-five under consideration.

Years with killing frosts occurred in series; from 1881 to 1888 there were no killing frosts; damaging frosts occurred in six years in succession, 1888 to 1893; in the succeeding years the frosts were somewhat more evenly distributed.

It can be seen from this summary that the average date at which the last killing frost is likely to occur in any locality is a matter of great importance to the fruit grower. In fact, this date, for the average year, or as a normal event, must often determine the limit in latitude or altitude at which a fruit can be grown. Even in the most favored fruit regions of the State the records bring out the fact that killing frosts must be expected, occasionally, to destroy the fruit crop wholly or in part. No season passes but that some loss is caused by late spring frosts in some part of New York.

There is a difference in the degree of cold that will injure blossoms and the developing ovaries of fruit of the several species. Table I shows the temperatures which are liable to injure setting fruit. The table has been compiled from scattering information from all parts of the United States as well as from the reports of these county committees in New York. Investigation of all the fruits in one locality for a long period of years would probably change more or less the data given. It will never be possible to fix definite temperatures at which setting fruits are injured, for several conditions change them; as, humidity of the air, cloudiness, diffuseness of sunlight, atmospheric pressure and possibly individuality of the plant. There are known to be, too, slight differ-

ences as to the degree of cold that will injure different varieties of a fruit at this stage of development.

TABLE I.— TEMPERATURES WHICH INJURE SETTING OF FRUITS.

FRUIT.	In bud.	In blossom.	In setting fruit.
	Degs. F.	Degs. F.	Degs. F.
Almonds	28	30	30
Apples	27	29	30
Apricots	30	31	32
Grapes	31	31	30
Peaches	29	30	30
Pears	28	29	29
Plums	30	31	31
Strawberries	28	28	28
Raspberries	28	28	28
Blackberries	28	28	28

A point well brought out in some of the discussions which followed the presentation of the reports quoted was that frost injury may be of all degrees, both as to the number of blossoms killed and as to the effects on individual blossoms. It does not appear from these discussions, however, or from any information which the writer can obtain, that one can distinguish exactly the degree of injury suffered by a blossom; nor even tell in all cases very accurately the percentages of buds that are killed outright; though withered, blackened reproductive organs — more especially the pistil — usually indicate that the viability of the blossom is destroyed. The loss from light frosts in most cases has been very greatly overestimated.

In examining the records of killing frosts for this region, one is struck with the number of times that such frosts, or, at least considerable falls in temperature, occur in the first week in June. The cause of this relapse in temperature, and of its somewhat regular occurrence, has not, to the writer's knowledge, been explained. In the colder portion of the State where fruit growing is carried on at a risk, owing to spring frosts, this week in June is the most dangerous period of the season. It corresponds to the "Eismänner" (ice-men) days of Germany, so-called because on the 12th, 13th and 14th days of May, dates on which Pancratius, Servatius, and Bonifacius are honored, there usually occur abnormally cold nights which often do incalculable damage to fruits and tender vegetation.

It does not appear that much has ever been done in this State in the way of averting frosts. Truth is, not much can be done. Whitten[1] has shown that injury from late spring frosts may sometimes be averted by whitewashing trees, a process which delays blooming a short time — in some seasons long enough to prevent injury from a late spring frost. The reason for the retarding of the blossoms is that the operation covers the dark wood with white, a color which does not absorb so much of the heat of the sun. There seems to be no record in the reports under consideration of this having been tried in New York. I very greatly doubt, after having had some experience in whitewashing trees, whether in the average season it is worth while as a means of preventing injury from late frosts. In a season of very bright sunshine, some benefit might accrue. It may be noted that the effect of spraying with lime and sulphur, or with bordeaux mixture, both of which give a light color to the wood, if applied at the right time, is to retard blossoming time.

The influence of windbreaks in mitigating the effects of late spring frosts is a mooted question. From the experience of fruit growers in western New York, their value seems to depend largely upon the topography of the land. A windbreak dense enough and so situated as to prevent circulation of the air can only be detrimental. So planted as to deflect or to cause air currents they become of value in keeping off frosts. More often than not, however, we are told, they seriously check atmospheric drainage and the damage by frost is increased. Another disadvantage often spoken of is that, should the windbreak be to the north and of evergreens, as is usually the case, the buds on the trees thus sheltered are forced and are therefore more liable to injury by late frosts. Of course this difficulty can be obviated somewhat by planting deciduous trees for the shelter, as these, coming in leaf in the spring, would not hasten the opening of blossoms.

White-washing and windbreaks are inadequate to avert injury from frosts in this State. More and more the fruit-grower must come to realize that he must secure the greatest possible degree of immunity from frosts by selecting frost-free locations and frost-proof fruits.

In choosing a site for an orchard both the climate of the locality and the climate of the plantation must be considered. In the first instance latitude, altitude and proximity to water are the chief de-

[1] Mo. Sta. Bul. 38, 1897.

terminants. The table at the close of this topic giving the average dates of killing frosts at a number of stations in New York should be helpful in choosing a fruit region or locality.

In the climate of a plantation the lay of the land is the governing factor. Every fruit plantation has a local climate varying in the different parts of the tract in accordance with the lay of the land. Low-lying spots show the greatest extremes — lowest temperature in cold weather and highest temperature in hot weather. Conversely on the elevated portions of a tract the temperature is most equable — less cold in low temperatures, less hot in high temperatures. The direction of the slope of the ground causes variation in the temperature probably because of the greater amount of heat absorbed from the sun by southerly slopes and because of the different exposures to prevailing winds. A slope also gives better air drainage than a level. These are well-known facts and yet they are not applied as often as they should be in planting orchards. The difference between high land and hollow, slope and plain, is often amply sufficient to account for the idiosyncrasies in frost injuries so often noted.

Some fruit growers in the State claim to obtain a certain degree of immunity from frost through good air drainage secured by planting at a sufficient distance so that tops do not touch and by keeping the heads within bounds by pruning.

Quite as essential as location in doing the little that can be done to avert frost injury is the selection of varieties. Some varieties of each of the several fruits blossom later than others and these are usually in least danger of frosts. The length of time during which different varieties are in blossom is worth considering though it varies considerably in accordance with the fruit, the variety, and most of all the weather. The table of blossoming dates, pages 452 to 475, should be a fairly accurate guide as to these points.

It is unfortunate that there are so few statements from fruit-growers or experimenters as to the comparative hardiness of varieties of the several fruits to frost. The only information in the discussions of frost injury in western New York is, that Wealthy, Fameuse and its seedling McIntosh, and Oldenburg, are less easily injured by frost than other apples which are blossoming at the same time. There are great variations in the blossoms of the varieties of all fruits and it must be that the flowers of some sorts are better adapted to withstand cold than are those of others. Thus a decidedly cup-shaped corolla must form some protection from

cold, as should sepals and petals of heavy texture, or sepals with much pubescence. It would seem that short pistils and stamens would be less easily injured by frost than would long ones because better protected. A careful study of the biology of blossoms ought to show that some varieties are much less easily injured at blooming time by frost than others.

The writer has given in a paper read before the New York State Fruit Growers' Association in 1907 a list of peaches hardy and tender as regards frosts and a report of an investigation which shows that there is considerable difference in peaches as to susceptibility to injury from frost.[1]

Less easy to understand is the fact often reported that there is a difference in the individual trees of a variety as to the susceptibility to frost injury. We are forced to assume that the numerous trees of a variety vary in vitality and that those having most vitality are best able to withstand frost and low temperatures. Since the vitality of a tree is greatly influenced by the care it receives — pruning, cultivation, spraying and feeding, we may further assume that blossoms of trees well cared for, whereby thrifty, vigorous plants are produced, are less likely to be injured by frosts than those not well cared for. It may be laid down as a rule that a tree or a variety that ripens its wood well in the autumn, and stores up an abundance of plant food, will best endure frosts and trying weather conditions at flowering time. If the assumption should prove to be not well founded, certainly the treatment suggested is neither harmful nor a waste of energy. It is at least believable that a thrifty tree, covered with blossoms each giving off an appreciable amount of heat and moisture, should have more blossoms set fruit than a less vigorous tree with a less number of blossoms.

Experiences in California and Florida in fighting frosts warrant the statement that much of the loss from light frosts in growing grapes and small fruits, at least, can be prevented. Indeed, there are seemingly no reasons why the losses from such frosts, considered unavoidable in the tree-fruit orchards of New York, cannot be prevented as well as in the citrus orchards of California and Florida.

In frost fighting the fruit-grower must keep in daily touch with the nearest Weather Bureau office. He should, too, be provided with several simple instruments for determining the dew-

[1] Report of New York State Fruit-Growers Association, 1908.

point, the temperature, and the motion of the air. Of the several methods used in protecting orchards against frosts, two commend themselves to the fruit-grower of this region; namely, one based on the warming of the air, and the other on the production of a dense cloud of smoke.

Small fires placed at proper intervals have been found capable of raising the temperature of an orchard several degrees. Wire baskets several feet above ground holding coal or wood have been found the most efficient, though torches, oil pots, and other such devices have been used. advantageously. From twenty to forty fires per acre are required.

Smudging is cheaper but less effective, chiefly because the smoke is too often carried out of the orchard by winds. Prunings, straw, manure, litter of all kinds, tar and crude oil have been used for smudging. In the case of the first named materials the burning litter is moistened as it burns thus producing a dense, steamy smoke which acts as a screen to prevent loss of heat by radiation; the heat of the fire raises the temperature somewhat, and the smoke may also screen the plants from the sun in the early morning. This method of frost-fighting is in use in some of the vineyards of New York.

In concluding this topic it must be said that methods of fighting frosts are still uncertain and in the experimental stage — especially in New York. The several proprietary compositions for burning, and the devices for making and distributing smoke, manufactured in European countries, but now being offered in America, have not been thoroughly tried in this country, and since tests seem to show them of doubtful utility abroad, both because of lack of efficiency and cost, they may well be left alone for the present in this State.

The importance of the average date of the last killing frost in spring to the fruit-grower, has been noted. Table II gives this information for New York. The records of killing frosts in 96 stations in the State were used, and for the years 1897 to 1906 inclusive, in preparing the table.

By *killing frost* is meant one which causes the death of the tender vegetation of the plants ordinarily cultivated in the region under discussion. It is generally considered by phenologists that the last killing frost more than any other weather event, characterizes the advent of spring. Consideration will show that the fruit-grower as well as the phenologist must accept the last frost as

heralding the season when buds may swell and blossoms burst forth.

Table II brings out several points of interest. It shows, beside the main point of average date: (1) How profoundly altitude and proximity to large bodies of water influence spring frosts. (2) The great range in time of killing frosts in different parts of the State. (3) That if blossoming dates are known, the limits of the growth of any fruit as to climate, can be told. (4) The average date of the advent of spring in the various localities. (5) That spring is two months in passing from the southern to the northern boundary, and from the valleys to the hill tops of New York.

In using the table it must be remembered that the time elapsing between the date of killing frosts on the average, and that date in any one year, may vary greatly. Thus in the ten-year period we are considering, frosts have occurred at Geneva as late as May 11 (in 1902); and the latest frost has fallen as early as April 9 (in 1898), giving a range from the average of 12 days in the first instance and of 32 days in the second. Allowances must be made, too, for local topographical features which are, as we have seen, quite as important oftentimes as the more general land features.

TABLE II.—DATES OF LAST KILLING FROSTS IN NEW YORK FROM 1897 TO 1906 INCLUSIVE.

STATIONS.	County.	Earliest.	Latest.	Average.
Addison	Steuben	April 9, 1898	May 22, 1897	May 3
Albany	Albany	April 9, 1898	May 11, 1902	April 23
Alden	Erie	April 20, 1901	May 15, 1902	May 1
Alfred	Allegany	April 18, 1899	June 22, 1897	May 14
Angelica	Allegany	May 9, 1898	June 21, 1897	May 23
Appleton	Niagara	April 17, 1899	May 11, 1902	Apri 30
Arcade	Wyoming	April 17, 1899	July 11, 1898	May 25
Atlanta	Steuben	April 27, 1901	May 31, 1903	May 17
Auburn	Cayuga	April 22, 1904	May 15, 1899	May 1
Avon	Livingston	April 20, 1901	May 31, 1903	May 14
Baldwinsville	Onondaga	April 11, 1899	May 14, 1902	April 26
Bedford	Westchester	April 13, 1901	May 29, 1900	April 30
Binghamton	Broome	April 13, 1898	May 22, 1897	April 30
Bolivar	Allegany	May 12, 1904	June 16, 1898	May 30
Bouckville	Madison	April 3, 1898	May 24, 1905	May 4
Brockport	Monroe	April 19, 1901	May 11, 1902	April 30
Buffalo	Erie	April 4, 1899	May 6, 1898	April 23
Caldwell	Warren	April 23, 1904	May 14, 1902	May 3
Canajoharie	Montgomery	April 4, 1898	May 30, 1902	May 7
Canton	St. Lawrence	April 27, 1901	June 11, 1902	May 18
Carmel	Putnam	Mar. 31, 1901	May 10, 1902	April 22
Carvers Falls	Washington	April 23, 1904	May 25, 1903	May 13
Catskill	Greene	April 11, 1899	April 22, 1897	April 13
Cedar Hill	Albany	April 6, 1898	May 12, 1902	April 25
Cooperstown	Otsego	April 17, 1901	May 22, 1897	May 15
Cortland	Cortland	May 9, 1898	June 6, 1902	May 18
Cutchogue	Suffolk	Mar. 31, 1901	May 10, 1900	April 19
Elba	Genesee	April 20, 1901	May 11, 1902	May 1
Elmira	Chemung	April 5, 1898	May 17, 1899	April 29
Fayetteville	Onondaga	May 2, 1905	May 31, 1903	May 15
Franklinville	Cattaraugus	April 28, 1898	June 10, 1901	May 22
Geneva	Ontario	April 9, 1898	May 11, 1902	April 23
Glens Falls	Warren	April 12, 1901	May 25, 1903	May 7
Gloversville	Fulton	April 23, 1904	May 31, 1902	May 6
Greenwich	Washington	April 23, 1904	May 21, 1902	May 7
Griffin Corners	Delaware	May 12, 1904	May 25, 1903	May 19
Hemlock Lake	Livingston	April 13, 1901	May 10, 1902	April 29
Honeymead Brook	Dutchess	April 13, 1901	May 10, 1902	May 2
Humphrey	Cattaraugus	April 28, 1898	May 29, 1902	May 16
Indian Lake	Hamilton	May 16, 1901	June 12, 1904	June 2
Ithaca	Tompkins	April 12, 1901	May 10, 1902	April 30
Jamestown	Chautauqua	April 21, 1901	May 29, 1902	May 8
Keene Valley	Essex	April 5, 1898	June 11, 1902	May 10
Liberty	Sullivan	April 6, 1898	May 16, 1902	May 1
Little Falls	Herkimer	April 12, 1901	May 15, 1899	May 1
Lockport	Niagara	April 9, 1898	May 11, 1902	April 23
Lowville	Lewis	April 27, 1901	May 22, 1897	May 8
Lyons	Wayne	April 8, 1898	May 11, 1902	April 21
Middletown	Orange	April 1, 1902	May 2, 1903	April 11
Mohonk Lake	Ulster	April 3, 1901	May 10, 1902	April 20
Moira	Franklin	April 23, 1904	May 25, 1903	May 11
New Lisbon	Otsego	May 8, 1897	June 11, 1899	May 22
New York	New York	Mar. 16, 1905	April 20, 1904	April 5
North Hammond	St. Lawrence	April 19, 1898	May 25, 1903	May 1
Number Four	Lewis	May 2, 1903	June 10, 1901	May 18
Nunda	Livingston	April 17, 1899	May 21, 1902	May 6
Ogdensburg	St. Lawrence	April 9, 1898	May 21 1897	April 28
Oneonta	Otsego	April 17, 1901	May 21, 1902	May 7
Oswego	Oswego	April 6, 1903	May 10, 1902	April 21
Oxford	Chenango	May 2, 1905	May 21, 1902	May 11
Oyster Bay	Nassau	April 20, 1905	May 3, 1903	April 24
Palermo	Oswego	April 13, 1901	May 16, 1899	May 4
Penn Yan	Yates	April 9, 1901	May 15, 1899	May 3
Perry City	Schuyler	May 2, 1903	June 16, 1898	May 20
Plattsburg	Clinton	April 19, 1898	June 23, 1899	May 19
Port Jervis	Orange	April 17, 1901	May 10, 1900	April 29
Potsdam	St Lawrence	April 23, 1904	May 25, 1903	May 6
Poughkeepsie	Dutchess	April 22, 1899	May 9, 1898	May 3
Primrose	Westchester	April 9, 1898	May 11, 1900	April 24
Richmondville	Schoharie	April 23, 1904	May 21, 1902	May 6
Ridgeway	Orleans	April 17, 1899	May 26, 1897	May 1
Rochester	Monroe	Mar. 29, 1901	May 11, 1902	April 20
Rome	Oneida	April 13, 1898	May 29, 1902	May 7

TABLE II.— (*Continued.*)

STATIONS.	County.	Earliest.	Latest.	Average.
Romulus	Seneca	May 2, 1903	May 26, 1897	May 12
Saranac Lake	Franklin	May 3, 1899	June 11, 1902	May 19
Saratoga Springs	Saratoga	April 13, 1901	May 16, 1902	April 30
Schenectady	Schenectady	May 11, 1900	May 15, 1899	May 13
Setauket	Suffolk	Mar. 31, 1901	May 27, 1902	April 17
Shortsville	Ontario	April 20, 1901	May 31, 1903	May 6
Southampton	Suffolk	Mar. 31, 1901	May 26, 1903	April 20
South Canisteo	Steuben	May 2, 1903	June 16, 1898	May 22
South Kortright	Delaware	May 12, 1904	June 11, 1899	May 26
South Schroon	Essex	April 23, 1904	May 29, 1902	May 16
Spier Falls	Saratoga	April 24, 1904	May 2, 1905	April 29
Strait's Corners	Tioga	April 4, 1904	July 12, 1898	May 21
Syracuse	Onondaga	April 22, 1905	May 2, 1903	April 25
Ticonderoga	Essex	April 6, 1898	May 24, 1903	April 29
Volusia	Chautauqua	April 21, 1901	May 11, 1902	May 1
Wappingers Falls	Dutchess	April 13, 1901	May 11, 1900	April 25
Watertown	Jefferson	April 17, 1899	July 11, 1898	May 9
Waverly	Tioga	May 2, 1903	May 29, 1902	May 15
Wedgewood	Schuyler	April 20, 1901	May 22, 1898	May 5
Wells	Hamilton	May 2, 1904	June 9, 1902	May 23
West Berne	Albany	April 19, 1899	June 5, 1903	May 8
Westfield	Chautauqua	April 17, 1899	May 7, 1900	April 27
Windham	Greene	April 23, 1904	May 31, 1903	May 18

RAIN AND FRUIT-SETTING.

Wet weather is reported to have almost wholly prevented the setting of fruit in the years 1881, 1882, 1883, 1886, 1890, 1892 and 1901.

Rain is mentioned as one of the causes of a poor setting of fruit in the years 1888, 1889, 1891, 1893, 1894, 1898, 1905.

Of the seasons given above, moisture came at blossoming time in the form of snow in 1889 and in 1891.

Gales of wind accompanied the rain in 1881, 1882, 1883 and 1905.

The rainfall came in periods of prolonged cold weather in the years 1881, 1882, 1883, 1886, 1888, 1889, 1891, 1892, 1894, 1898, 1905.

In 1890 the rainy weather was hot and sultry.

Frosts and cold weather accompanied the rains in 1888, 1889, 1890, 1891, and 1892. As will be observed, the two extremes of heat and cold accompanied the rains in 1890.

As in the case of frosts there are cycles of years of wetness. Thus, it rained with the destuction of blossoms in the period of the years 1881 to 1883, and in the longer period of seven years, beginning with 1888 and ending with 1894.

If we consider the above summary in connection with the more detailed accounts in the reports quoted we must conclude that rain and the cold and wind that usually accompany it at blossoming time,

cause the loss of more fruit than any other of the climatal agencies. The damage is done in several ways. The most obvious injury, and the one most often noticed by fruit growers, is the washing of the pollen from the anthers. The secretion on the stigmas, so essential to the proper germination of the pollen, also is often washed away or becomes so diluted that the pollen does not germinate. It is probable that the chill of rainy weather decreases the vitality of the pollen and an excess of moisture often causes pollen grains to swell and burst, thereby destroying their vitality. Quite as important as any of the above considerations, possibly more so, is the fact that rain prevents bees and insects from carrying pollen and must effectually prevent its distribution by wind, if wind doe distribute the pollen of fruits.

Weather conditions, and especially rain and a humid atmosphere, have much to do with the development of parasitic fungi. A wet May in New York brings an abundance of fungi of several species, which may destroy or injure blossoms and prevent the setting of fruit. While rain is the chief weather condition, it is not the only one that must be taken into consideration in this connection. With some fungi heat is a strong factor and with others, cold. Cloudy weather, too, or a humid atmosphere without rain will give favoring conditions for the growth of fungi.

In the long continued cold, rainy weather during the blooming time of 1907, there was an excellent opportunity to observe the behavior of blossoms on the Station grounds. Not only did such weather hinder the transferrence of pollen, but the pollen did not form in the anthers in normal quantities and was not expelled from them. The secretion in the stigmas seemed diluted and watery, so that the pollen grains, either because of such dilution, or in consequence of the cold, or because of both, did not germinate properly.

If as Ewert[1] holds, pollination is not absolutely necessary for some varieties of apples and pears it is still true that cold, rainy weather is most unfavorable for the setting of these apples quite aside from its effects in preventing the impregnation of the ovary. Such weather prevents the development of the young fruits whether fertilized or unfertilized. In the latter case the young fruits do not have the stimulus of an impregnated ovary to assist in overcoming the deleterious effects of the unfavorable weather.

The average rainfall for May in the different parts of New

[1] Ewert. Blutenbiologie und Tragbarkeit unserer Obstbaüme. *Landw. Jahrb.*, 35: 258–287, pls. 2, 1906.

York for the ten years from 1897 to 1906, is shown in Table III. A study of the table shows that the amount of rainfall is increased by proximity to large bodies of water, as the ocean and the Great Lakes, and in accordance with the topography of the State. Marked increase is found in the highlands of the State; and ranges of hills or mountains which run at right angles to the direction of rainbearing winds, as those of the hill ranges of the southeastern counties, give a copious rainfall on the windward side of the obstruction. Where the land rises abruptly about the Great Lakes, too, the amount of precipitation is considerably increased. There is a marked deficiency in the May rainfall in the depression of the Central Lakes and in some of the river valleys, notably the valley of the Susquehanna, probably because of surrounding highlands which obstruct the passage of rainclouds. May is a wet month in New York, yet the total downfall is not great. The rains, however, are frequent or long continued and usually accompanied by cold, and in these conditions lies the power to injure blossems.

The average rainfall in May for all of the weather stations in New York for ten years was, from data in Table III, 3.06 inches. For the leading fruit counties, it is: Erie, 2.68; Niagara, 2.32; Onondaga, 2.56; Monroe, 2.12; Genesee, 2.56; Dutchess, 3.86; Chautauqua, 3.52; Wayne, 2.43; Yates, 2.16; Orleans, 2.65; Ontario, 2.46. It is interesting to note that for nine out of the eleven counties named above the average is considerably below that of the State.

TABLE III.—RAINFALL FOR MAY IN NEW YORK FROM 1897 TO 1906 INCLUSIVE.

STATION.	County.	Maximum.	Minimum.	Average.
		Ins.	Ins.	Ins.
Addison	Steuben	4.94–1901	1.78–1905	3.37
Albany	Albany	4.79–1901	0.96–1905	2.62
Alden	Erie	4.49–1901	1.51–1903	3.04
Alfred	Allegany	5.88–1901	3.07–1899	3.74
Angelica	Allegany	5.23–1901	1.16–1903	3.41
Appleton	Niagara	3.78–1905	1.05–1900	2.38
Arcade	Wyoming	4.92–1899	1.63–1903	3.61
Atlanta	Steuben	5.97–1901	1.16–1903	3.25
Auburn	Cayuga	5.37–1906	0.74–1903	3.70
Avon	Livingston	3.94–1904	0.45–1903	2.21
Baldwinsville	Onondaga	3.98–1902	0.50–1903	2.75
Bedford	Westchester	9.83–1897	0.24–1903	4.84
Binghamton	Broome	5.49–1901	0.42–1903	2.73
Bolivar	Allegany	4.93–1901	1.61–1905	3.32
Bouckville	Madison	5.79–1901	0.00–1903	3.19
Brockport	Monroe	4.02–1901	0.82–1903	2.16
Buffalo	Erie	3.28–1901	1.22–1900	2.32
Caldwell	Warren	4.57–1901	0.29–1903	2.36
Canajoharie	Montgomery	5.10–1901	0.07–1903	2.81
Canton	St. Lawrence	5.77–1901	2.69–1898	3.53
Carmel	Putnam	7.49–1901	1.68–1899	4.43
Carvers Falls	Washington	4.81–1901	0.05–1903	2.27
Catskill	Greene	5.81–1897	2.12–1899	4.06
Cedar Hill	Albany	5.27–1901	0.47–1903	3.79
Cooperstown	Otsego	7.35–1906	0.17–1903	3.74
Cortland	Cortland	5.73–1906	0.30–1903	3.12
Cutchogue	Suffolk	7.31–1901	0.84–1902	3.16
Elba	Genesee	5.13–1901	1.19–1903	2.56
Elmira	Chemung	5.56–1897	1.43–1900	3.41
Fayetteville	Onondaga	3.97–1902	0.22–1903	2.66
Franklinville	Cattaraugus	4.94–1901	1.91–1900	3.44
Geneva	Ontario	4.24–1906	0.23–1903	2.46
Glens Falls	Warren	5.83–1906	0.27–1903	2.59
Gloversville	Fulton	6.45–1898	0.16–1903	3.23
Greenwich	Washington	6.13–1906	0.57–1903	3.26
Griffin Corners	Delaware	5.47–1901	0.30–1903	2.73
Hemlock Lake	Livingston	4.55–1904	0.53–1903	2.86
Honeymead Brook	Dutchess	7.14–1898	1.20–1903	3.69
Humphrey	Cattaraugus	4.97–1901	3.13–1900	4.01
Indian Lake	Hamilton	4.88–1906	0.21–1903	2.85
Ithaca	Tompkins	4.64–1904	0.30–1903	2.96
Jamestown	Chautauqua	6.77–1904	1.95–1900	3.64
Keene Valley	Essex	5.72–1901	0.02–1903	2.60
Liberty	Sullivan	7.98–1898	0.44–1903	3.29
Little Falls	Herkimer	5.66–1901	0.06–1903	3.28
Lockport	Niagara	3.27–1901	1.30–1899	2.27
Lowville	Lewis	4.23–1906	0.67–1903	3.04
Lyons	Wayne	3.57–1898	0.15–1903	2.43
Middletown	Orange	6.90–1901	0.34–1903	3.53
Mohonk Lake	Ulster	8.75–1901	0.88–1903	3.72
Moira	Franklin	4.30–1900	0.05–1903	2.89
New Lisbon	Otsego	5.85–1906	0.25–1903	3.33
New York	New York	7.01–1901	0.33–1903	3.20
North Hammond	St. Lawrence	4.46–1901	0.16–1903	3.05
Number Four	Lewis	4.40–1905	0.45–1903	3.34
Nunda	Livingston	5.67–1901	0.56–1903	3.64
Ogdensburg	St. Lawrence	5.23–1901	0.17–1903	2.47
Oneonta	Otsego	7.42–1897	0.36–1903	3.34
Oswego	Oswego	4.14–1898	0.32–1903	2.71
Oxford	Chenango	7.69–1901	0.42–1903	3.75
Oyster Bay	Nassau	3.53–1906	0.40–1903	*2.20
Palermo	Oswego	4.10–1898	0.34–1903	2.25
Penn Yan	Yates	4.44–1901	0.30–1903	2.16
Perry City	Schuyler	5.61–1904	0.72–1903	3.11
Plattsburg	Clinton	4.38–1901	0.00–1903	2.53
Port Jervis	Orange	7.15–1898	1.00–1903	3.93
Potsdam	St. Lawrence	3.32–1905	0.18–1903	2.28
Poughkeepsie	Dutchess	4.74–1898	1.27–1899	3.19
Primrose	Westchester	7.91–1898	0.78–1903	4.33
Richmondville	Schoharie	5.22–1901	0.22–1903	2.33
Ridgeway	Orleans	4.66–1901	1.14–1903	2.65
Rochester	Monroe	3.86–1904	0.53–1903	2.09
Rome	Oneida	5.56–1901	0.03–1903	3.32
Romulus	Seneca	5.37–1901	0.25–1903	3.31

TABLE III.— (*Continued.*)

STATION.	County.	Maximum.	Minimum.	Average.
		Ins.	*Ins.*	*Ins.*
Saranac Lake	Franklin	4.31–1901	0.01–1903	2.79
Saratoga Springs	Saratoga	4.97–1901	0.44–1903	2.56
Schenectady	Schenectady	6.11–1901	1.92–1900	3.73
Setauket	Suffolk	8.30–1898	0.50–1903	3.81
Shortsville	Ontario	4.11–1906	0.29–1903	2.56
Southampton	Suffolk	7.95–1906	0.80–1902	3.46
South Canisteo	Steuben	5.15–1901	1.52–1905	3.21
South Kortright	Delaware	5.33–1897	0.25–1903	2.81
South Schroon	Essex	5.03–1901	0.10–1903	2.75
Spier Falls	Saratoga	5.55–1906	0.44–1903	2.31
Straits' Corners	Tioga	4.48–1901	0.17–1903	2.89
Syracuse	Onondaga	3.48–1904	0.28–1903	2.27
Ticonderoga	Essex	4.06–1901	0.52–1903	2.11
Volusia	Chautauqua	5.07–1899	1.47–1903	3.30
Wappingers Falls	Dutchess	7.65–1898	1.84–1905	4.71
Watertown	Jefferson	4.38–1906	0.49–1903	3.24
Waverly	Tioga	5.96–1901	0.76–1903	3.02
Wedgewood	Schuyler	5.31–1904	0.87–1903	3.23
Wells	Hamilton	4.59–1901	0.09–1903	2.63
West Berne	Albany	5.47–1901	0.22–1903	2.69
Westfield	Chautauqua	4.30–1899	2.44–1900	3.63
Windham	Greene	5.30–1896	0.92–1903	2.85

* From data of four years only.

TEMPERATURE AND THE SETTING OF FRUIT.

It is impossible to disassociate cold with frost and rain from cold weather unaccompanied by either of these phenomena, since a temperature low enough to be harmful to blossoms is usually associated with one or the other. Except where otherwise mentioned in the summaries regarding rain and frost it may be assumed that these elements were accompanied by cold. But it must be understood that a low temperature, even though it does not touch the frost point, nor is accompanied by rain, is often disastrous to the setting fruit. The injurious effect is probably due to the prevention of the growth of the pollen tube.

There is no definite information, so far as the writer knows, as to what is the minimum temperature for the germination of pollen of the different fruits under natural conditions. Mr. N. O. Booth, Assistant Horticulturist at this Station, who has had much experience in germinating pollen in the laboratory, says, roughly speaking, that the pollen of our several fruits germinates best indoors with a temperature of from 60°-70° F.; that it makes a feeble growth from 50°-60°; and does not grow as a rule, at a lower temperature than 50°. As would be expected there is some variation with the several fruits.

A period of cold weather seriously checks the development of fruit blossoms and even after the advent of warm weather the

blossoms are at a standstill for a time, seeming to have been checked in their power to grow by the chill. The evil effects of cold are greatly magnified when accompanied by rain. No condition of spring-time weather is as harmful to blossoms, except a killing frost, as a prolonged cold rain.

It is quite probable that hot weather also occasionally injures fruit blossoms, both by preventing the germination of the pollen, by acting directly on the pollen tube or by drying up the secretion of the stigma, or by "blasting" the blossom through too rapid growth. There is, in all probability, then, a certain range of temperature necessary for the best fecundation of fruit blossoms, though unfortunately there seems to have been no careful field work to determine either the maximum or the minimum temperatures for the process as it occurs at its best.

There seem to be no statements from direct experiments as to the comparative effects of high and low temperature on the sexes in blossoms but my own observation is that the stamens are more sensitive to heat or cold than the pistils. In 1901 while working with students in cross-pollination experiments it was found that the stamens of several varieties of apples and pears, after a wave of exceptionally hot weather, had developed much more rapidly than had the pistils, and that the anthers were bursting with pollen, while the stigmas were not yet receptive. The pollen was scattered before the stigmas became receptive. Normally, with the varieties observed, the stigmas matured with or somewhat before the anthers. Such observations as I have been able to make in the years since 1901 have convinced me of the correctness of the observation, for apple and pear fruits at least. Stamens seem to develop least rapidly in cold and, as with heat, are seemingly most affected by it; though the pistils are more easily injured by frosts. After a light frost it will almost invariably be found that many or all of the pistils are destroyed or badly injured while the stamens may be uninjured or may show but little damage.

In the current discussions of cross-pollination it is held that in some species and their varieties the stamens mature either before or after the stigmas become receptive, as the case may be. This is supposed to characterize the species or the variety. But it may be that the stamens will mature first one season and the pistils first another, according as to whether the weather is cool, temperate, or warm. This phase is one that deserves close attention from students of blossom biology.

Tha daily range in temperature.—The average daily range in temperature is an important constituent of blooming-time weather. When the daily range is highest the danger to blossoms is greatest. The most jeopardizing weather to the fruit crop, from the standpoint of temperature, consists of warm, sunny days, followed by still, cloudless, cold nights. The danger is all the greater in such stresses of weather because the heat of the day forces out the blossoms prematurely. Orchards on eastern or southern slopes or in sunny hollows are most endangered by such weather; for, in the case of the slopes, the early morning sun contributes to the frost injury, and in the case of the hollows cold air flows in from the surrounding higher ground and in the quiet of the hollow the temperature may sink several degrees below that of the higher ground; in both cases blossoms open prematurely.

Table IV shows the mean temperature for the month of May in New York and the maximum, minimum and greatest daily range of temperature for this month. All data are averages from the ten-year period under consideration and for the 96 weather stations of the State.

TABLE IV.— MEAN AND EXTREME TEMPERATURES AND AVERAGE GREATEST DAILY RANGE FOR THE MONTH OF MAY IN NEW YORK, FROM 1897 TO 1906 INCLUSIVE.

STATION.	County.	Maximum.		Minimum.		Mean.	Greatest daily range.
		Degs.	Year.	Degs.	Year.	Degs.	Degs.
Addison	Steuben	59.4	1900	55.5	1897	57.8	44
Albany	Albany	62.6	1904	57.0	1902	59.3	34
Alden	Erie	59.6	1903	55.3	1902	57.1	37
Alfred	Allegany	55.7	1900	52.5	1897	54.6	39
Angelica	Allegany	57.4	1904	52.5	1897	55.5	46
Appleton	Niagara	56.4	1904	53.6	1901	54.8	40
Arcade	Wyoming	56.0	1899	52.2	1897	54.6	42
Atlanta	Steuben	56.7	1904	54.0	1902	55.6	44
Auburn	Cayuga	60.6	1903	56.2	1902	58.2	39
Avon	Livingston	58.5	1904	54.6	1902	56.6	42
Baldwinsville	Onondaga	60.3	1904	56.4	1902	58.1	38
Bedford	Westchester	61.6	1904	56.0	1898	58.4	36
Binghamton	Broome	59.6	1904	55.0	1902	57.1	38
Bolivar	Allegany	56.6	1904	52.8	1897	54.9	49
Bouckville	Madison	59.0	1904	52.0	1905	55.0	38
Brockport	Monroe	60.3	1904	55.8	1902	57.5	39
Buffalo	Erie	60.4	1903	53.5	1906	55.5	30
Caldwell	Warren	59.9	1904	53.5	1900	56.4	39
Canajoharie	Montgomery	59.4	1904	54.2	1902	57.0	40
Canton	St. Lawrence	56.7	1898	51.9	1900	54.5	38
Carmel	Putnam	61.7	1904	55.8	1905	59.1	33
Carvers Falls	Washington	59.0	1904	52.5	1902	55.6	42
Catskill	Greene	58.8	1899	57.0	1898	58.1	32
Cedar Hill	Albany	60.8	1903	57.0	1902	59.0	41
Cooperstown	Otsego	57.8	1904	52.5	1902	54.7	36
Cortland	Cortland	59.8	1904	54.1	1897	56.9	40
Cutchogue	Suffolk	60.4	1903	54.8	1901	57.8	34
Elba	Genesee	59.0	1904	53.2	1902	55.9	35
Elmira	Chemung	62.0	1904	57.6	1901	59.3	40
Fayetteville	Onondaga	61.3	1904	55.8	1902	58.6	40
Franklinville	Cattaraugus	56.2	1904	52.8	1897	54.5	45
Geneva	Ontario	60.4	1903	55.4	1897	57.5	37
Glens Falls	Warren	60.4	1904	56.0	1906	57.8	40
Gloversville	Fulton	59.6	1904	53.5	1902	55.8	43
Greenwich	Washington	60.0	1904	55.0	1902	56.8	39
Griffin Corners	Delaware	55.7	1904	52.6	1902	53.8	43
Hemlock Lake	Livingston	59.2	1903	55.6	1902	57.1	35
Honeymead Brook	Dutchess	59.5	1903	56.2	1902	57.2	35
Humphrey	Cattaraugus	57.2	1899	52.4	1901	54.9	38
Indian Lake	Hamilton	54.6	1904	49.4	1902	52.5	49
Ithaca	Tompkins	59.6	1904	54.5	1902	56.6	37
Jamestown	Chautauqua	59.8	1903	53.4	1902	57.1	40
Keene Valley	Essex	58.5	1904	51.2	1898	53.8	44
Liberty	Sullivan	58.6	1904	53.0	1898	55.8	36
Little Falls	Herkimer	62.4	1903	53.6	1902	56.0	34
Lockport	Niagara	59.2	1903	55.2	1906	57.1	39
Lowville	Lewis	57.8	1904	52.4	1902	54.3	42
Lyons	Wayne	62.6	1904	56.3	1897	58.8	36
Middletown	Orange	61.6	1904	56.2	1898	59.0	32
Mohonk Lake	Ulster	59.9	1904	54.9	1898	57.0	28
Moira	Franklin	60.3	1904	53.0	1902	55.8	39
New Lisbon	Otsego	55.8	1904	51.6	1902	53.1	45
New York	New York	64.1	1903	56.6	1898	60.6	27
North Hammond	St. Lawrence	61.0	1903	53.6	1902	56.6	35
Number Four	Lewis	56.8	1903	50.2	1897	52.6	39
Nunda	Livingston	59.2	1903	55.8	1902	57.5	44
Ogdensburg	St. Lawrence	61.9	1904	53.3	1902	56.4	36
Oneonta	Otsego	60.8	1904	54.7	1902	57.3	44
Oswego	Oswego	56.7	1904	52.4	1905	54.1	32
Oxford	Chenango	59.3	1904	55.0	1902	56.4	43
Oyster Bay	Nassau	61.6	1904	59.8	1906	61.0	†37
Palermo	Oswego	55.9	1900	54.0	1897	55.4	41
Penn Yan	Yates	59.7	1903	55.9	1902	58.3	39
Perry City	Schuyler	58.4	1904	53.6	1902	55.7	44
Plattsburg	Clinton	60.4	1904	49.7	1899	54.8	42
Port Jervis	Orange	62.3	1904	58.2	1897	59.8	41
Potsdam	St. Lawrence	60.2	1904	54.6	1897	56.4	39
Poughkeepsie	Dutchess	59.0	1899	57.0	1898	57.8	*41
Primrose	Westchester	61.4	1904	56.4	1898	59.0	39
Richmondville	Schoharie	59.5	1904	54.4	1902	56.4	42
Ridgeway	Orleans	58.4	1904	54.2	1897	56.1	35
Rochester	Monroe	59.8	1904	55.5	1897	57.2	34

TABLE IV.— (*Continued.*)

STATION.	County.	Maximum.		Minimum.		Mean.	Greatest daily range.
		Degs.	*Year.*	*Degs.*	*Year.*	*Degs.*	*Degs.*
Rome	Oneida	61.3	1904	54.2	1900	56.9	38
Romulus	Seneca	60.4	1904	55.0	1902	57.8	38
Saranac Lake	Franklin	57.4	1904	50.2	1902	53.0	42
Saratoga Springs	Saratoga	59.5	1904	55.0	1900	56.7	40
Schenectady	Schenectady	59.7	1901	58.2	1900	59.1	*39
Setauket	Suffolk	60.3	1904	56.2	1898	58.2	30
Shortsville	Ontario	59.4	1903	55.0	1902	56.8	38
Southampton	Suffolk	58.1	1903	53.8	1901	56.1	26
South Canisteo	Steuben	58.8	1903	53.5	1897	55.8	43
South Kortright	Delaware	57.2	1904	52.9	1902	54.6	45
South Schroon	Essex	57.3	1904	51.8	1902	53.9	42
Spier Falls	Saratoga	61.4	1904	56.8	1906	58.8	47
Straits' Corners	Tioga	58.3	1904	53.4	1902	55.9	42
Syracuse	Onondaga	60.1	1904	56.2	1906	57.8	32
Ticonderoga	Essex	60.6	1904	54.0	1906	57.0	40
Volusia	Chautauqua	57.9	1903	54.2	1901	55.7	36
Wappingers Falls	Dutchess	61.1	1897	58.4	1898	60.0	39
Watertown	Jefferson	59.8	1904	53.8	1902	56.5	37
Waverly	Tioga	60.8	1904	56.0	1897	58.2	47
Wedgewood	Schuyler	58.6	1899	54.0	1902	55.8	34
Wells	Hamilton	57.2	1904	53.6	1902	54.9	49
West Berne	Albany	62.6	1899	55.0	1900	56.9	47
Westfield	Chautauqua	58.2	1899	55.2	1897	56.9	36
Windham	Greene	58.1	1904	52.6	1900	55.2	44

*Average for three years. †Average for two years.

Inspection of the table shows the modifying effects of the Ocean, Great Lakes, and Central Lakes on the temperature in general and especially in the daily range of temperature. Near these bodies of water the daily range is much less than in other parts of the State. The small daily range is brought about through the equalizing effect of the water and through the comparative cloudiness of these regions. The shelter given by the surrounding hills helps also to render the valleys of the Central Lakes equable as to temperature.

The other general features which influence the position and trend of isothermal lines are: Latitude, altitude, and circulation of air.

The difference between the daily range for May in the several fruit regions of the State is shown in Table V, the average being taken for all of the stations in each fruit region and for the ten-year period.

TABLE V.— AVERAGE GREATEST DAILY RANGE IN THE FRUIT REGIONS OF NEW YORK.

Long Island	31	Eastern Plateau	40
Hudson Valley	38	Central Lakes	39
Northern Plateau	43	Western Plateau	42
St. Lawrence Valley	37	Ontario Shore	36
Mohawk Valley	39	Erie Shore	34

This table shows even better than the former one the equalizing effect of water through its thermal stability as compared with the rapidity of radiation and absorption of heat from land.

SUNSHINE AND THE SETTING OF FRUIT.

Sunny weather is reported at blooming-time in western New York in the years 1885, 1887, 1896, 1897 and 1900. In each of the above years the sunshine was accompanied by warm, dry weather. It is a most significant fact that there were good crops of fruit in all of the years named and that in three of them there were record-breaking crops of one or another of the fruits and enormous crops of practically all of the tree-fruits.

When the atmosphere is well warmed and dried by the rays of the sun the essential organs develop more quickly and at maturity are normal and healthy. Pollen is produced under such conditions in greater quantities and has more vitality, while the stigmas show a greater amount of the secretion which is necessary for the germination of the pollen. The experience of centuries has confirmed the value of sunshine in blossoming-time, and has shown the desirability of a region for fruit growing in which the blossoming-time is a season of sunshine. It is only during warm sunny weather that insects will work; even cloudiness without rain or cold has a depressing effect on the energies of insects. The nectar which attracts insects seems to be formed in quantities worth seeking only when the sun is shining.

It is true that warm weather and bright sunshine sometimes hasten floral expansion so that there is not time for proper cross-pollination, but this seldom occurs. Under normal conditions the several tree fruits are in blossom until all ovaries are fertilized, the dropping of the petals and the withering of the pistils and stamens being a sign that fertilization has taken place.

It is an interesting fact that the floral envelope is developed nearly as well, with some plants at least, in darkness as in light. Thus, lilacs and other flowering shrubs may be and often are forced into flower in dark cellars. But in flowers so forced stamens and and pistils are diminutive as compared with those which have developed in full sunshine and the pollen is developed in comparatively small quantities and but little of it seems plump and perfect, though seemingly no tests have been made to ascertain its germinative

power. The effects of darkness are produced in a lesser degree in the absence of sunlight in those regions where clouds or fogs prevail.

It is possible that there may be considerable watery vapor in the air, even though the sun is shining brightly. This invisible vapor in the air at blooming-time may have an unfavorable effect upon the reproductive organs of a plant, for the chemical effects of the sun's rays must vary with the humidity of the air and the moisture must have a direct effect upon them. There seems to be known but little that is definite in regard to such humidity. The florist knows that a dry atmosphere is much preferable to a humid one for the setting of tomatoes, cucumbers and melons in the greenhouse, and we may assume that this is as true out of doors as in doors.

It is well known that dry air allows heat to escape by radiation more quickly than does a moist atmosphere. Other factors being the same, frost, therefore, is more severe in dry, sunny weather than in moist or cloudy weather. Excessively dry air, too, often causes a greater transpiration from leaf and flower than the roots can supply and if a wind arise the organs are dried up; so, too, a hot sun may parch the reproductive and floral organs. But these ills of dry, hot weather are not commonly felt at blooming time in New York.

WIND AND THE SETTING OF FRUIT.

Wind of sufficient strength to damage blossoms is mentioned in the reports we are considering in the years 1881, 1882, 1883, and 1895.

In the years when rainfall was detrimental to the blossoms, wind is mentioned several times as an accompaniment.

Wind is not mentioned in any of the years of frostiness.

It is certain that wind at blossoming-time may be injurious and we may assume that it is sometimes beneficial. Its effects may be summarized as follows:

Injurious effects.— Strong winds may blow or whip blossoms from the trees and prevent insects from working. Long continued, warm, dry winds injure blossoms by evaporating the secretion from the stigmas, thereby preventing the retention and germination of pollen; such winds often do much damage in bleak regions. Damp, warm winds, if long continued, are unfavorable to pollination and fertilization. A cold, dry, north wind in blooming-time often proves exceedingly unfavorable to the fruit crop. Such a wind

seems to chill vegetation and stops the normal functions of not only flowers but of leaves, the latter sometimes experiencing a set-back from which they never entirely recover. Lastly, winds may carry germs of plant diseases harmful to the plant — as for instance pear blight.

Beneficial effects.— The wind may aid in the distribution of pollen though it is doubtful if much good is done by air currents in this way. On cold, clear nights, winds keep off frosts by renewing the heat; or by bringing fogs or clouds from lakes or ocean frosts are prevented on the leeward side of the water.

A study of the above effects and of conditions as they prevail in New York shows that winds do comparatively little damage in this State in blooming-time. The topography of the State, the amount of water in and surrounding the region, and timber lands give, for most part, favorable winds in the spring of the year, though occasionally considerable damage is done by high winds. Windbreaks are of doubtful value in protecting blossoms from wind, and probably decrease the beneficial effects of winds more than they mitigate the injurious effects.

Table VI shows the days of sunshine and cloudiness and the direction of the prevailing wind at the 96 weather stations in New York. The regions having the greatest precipitation have the most cloudy weather, though rainfall and cloudiness are not exactly proportional in the several regions.

The influence of the Great Lakes on the winds which pass over them is very marked in fruit districts adjacent to these bodies of water. Data collected by the U. S. Weather Bureau indicate that the surface of Lake Erie and Lake Ontario averages from 10° to 15° warmer in winter and cooler in summer than the nearby land. The tempering effects of winds are very marked in the area south and east of the Lakes but decrease rapidly toward the interior of the State.

Most of the best fruit localities in the fruit districts of the State are in valleys or are sheltered by highlands. This sheltering effect of hills and highlands is an important factor in choosing orchard sites and can be made use of as a protection from winds to a great extent in a territory so irregular as New York.

The night-blowing valley winds are important climatic factors in fruit growing in keeping off frost and in tempering cold of winter and heat of summer. These nocturnal winds usually begin blowing in valleys a few hours after sunset and pass down the

valley channel with a velocity from 10 to 20 miles per hour. They are seldom felt on the upper hill slopes of valleys and of course not at all on the plains.

On Long Island and near the ocean the land wind and the sea breeze modify the climate not a little. The former blows off the shore at night in fair weather and the latter sets in from the sea at about the middle of the morning and blows until toward sunset. These winds affect the climate from ten to twenty miles inland and must have a marked influence on the early-blooming fruits.

TABLE VI.— AVERAGE NUMBER OF CLEAR, OF PARTLY CLOUDY, AND OF CLOUDY DAYS, AND PREVAILING DIRECTION OF THE WIND FOR THE YEARS 1897 TO 1906, INCLUSIVE.

Station.	County.	No. of clear days.	No. of partly cloudy days.	No. of cloudy days.	Prevailing direction of wind.
Addison	Steuben	16	8	7	S.W.
Albany	Albany	12	9	10	S.
Alden	Er e	14	11	6	W.
Alfred	Allegany	9	11	11	S.W.
Angelica	Allegany	9	14	8	W.
Appleton	Niagara	11	12	8	W.
Arcade	Wyoming	12	9	10	W.
Atlanta	Steuben	8	9	14	W.
Auburn	Cayuga	17	9	5	N.
Avon	Livingston	15	9	7	——
Baldwinsville	Onondaga	16	6	9	——
Bedford	Westchester	15	8	8	S.W.-W.
Binghamton	Broome	9	11	11	N.W.
Bolivar	Allegany	7	14	10	S.W.
Bouckville	Madison	9	8	14	N.W.
Brockport	Monroe	12	13	6	S.W.
Buffalo	Erie	6	14	11	S.W.
Caldwell	Warren	13	8	10	S.
Canajoharie	Montgomery	15	8	8	W.
Canton	St. Lawrence	9	11	11	W.
Carmel	Putnam	17	3	11	S.W.
Carvers Falls	Washington	16	9	6	S.
Catskill	Greene	7	14	10	S.
Cedar Hill	Albany	15	6	10	S.
Cooperstown	Otsego	10	12	9	N.W.
Cortland	Cortland	13	11	7	N.W.
Cutchogue	Suffolk	18	9	4	S.W.
Elba	Genesee	9	5	17	S.W.
Elmira	Chemung	14	8	9	N.W.
Fayetteville	Onondaga	15	9	7	N.W.
Franklinville	Cattaraugus	9	11	11	S.
Glens Falls	Warren	8	7	16	S.W.
Gloversville	Fulton	13	9	9	W.
Greenwich	Washington	11	10	10	S.W.
Griffin Corners	Delaware	17	8	6	W.
Hemlock Lake	Livingston	13	8	10	N.W.
Honeymead Brook	Dutchess	8	11	12	S.W.
Humphrey	Cattaraugus	5	12	14	S.W.
Indian Lake	Hamilton	10	11	10	N.-W
Ithaca	Tompkins	10	10	11	N.W.
Jamestown	Chautauqua	8	16	7	N.W.
Keene Valley	Essex	15	7	9	S.-N.W.
Liberty	Sullivan	16	9	6	N.W.
Little Falls	Herkimer	17	7	7	W.
Lockport	Niagara	12	10	9	W.-S.W.
Lowville	Lewis	12	12	7	W.
*Lyons	Wayne	13	10	8	N.W.
Middletown	Orange	15	9	7	N.W.
Mohonk Lake	Ulster	11	10	10	S.W.
Moira	Franklin	11	11	9	W.
New Lisbon	Otsego	9	9	13	S.-N.W.-S.W.
New York	New York	11	10	10	N.W.
North Hammond	St. Lawrence	7	12	12	W.
Number Four	Lewis	11	9	11	S.
Nunda	Livingston	12	11	8	N.E.
Ogdensburg	St. Lawrence	9	13	9	S.W.
Oneonta	Otsego	18	5	8	N.W.
Oswego	Oswego	9	11	11	W.
Oxford	Chenango	7	17	7	S.
†Oyster Bay	Nassau	13	11	7	S.-N.E.-S.E.
Palermo	Oswego	11	11	9	W.S.W.
Penn Yan	Yates	9	8	14	N.W.
Perry City	Schuyler	10	10	11	N.-N.W.
Plattsburg	Clinton	15	11	5	S.
Port Jervis	Orange	15	9	7	S.W.
Potsdam	St. Lawrence	19	4	8	S.W.
*Poughkeepsie	Dutchess	7	11	11	N.
Primrose	Westchester	9	15	7	——
Richmondville	Schoharie	18	6	7	W.
Ridgeway	Orleans	12	14	5	E.
Rochester	Monroe	10	11	10	S.W.
Rome	Oneida	15	9	7	E.

TABLE VI.—(*Continued.*)

Station.	County.	No. of clear days.	No. of partly cloudy days.	No. of cloudy days.	Prevailing direction of wind.
Romulus	Seneca	11	9	11	S.
Saranac Lake	Franklin	11	12	8	N.W.-W.
Saratoga Springs	Saratoga	10	12	9	S.W.
*Schenectady	Schenectady	14	7	10	W.
Setauket	Suffolk	13	8	10	S.
Shortsville	Ontario	12	10	9	N.E.
Southampton	Suffolk	16	11	4	S.W.
South Canisteo	Steuben	12	7	12	N.W.
South Kortright	Delaware	18	7	6	S.W.
South Schroon	Essex	14	7	10	S.
Spier Falls	Saratoga	16	8	7	S.W.
Straits Corners	Tioga	15	6	10	N.
Syracuse	Onondaga	8	16	7	S.
Ticonderoga	Essex	17	5	9	S.
Volusia	Chautauqua	13	14	4	S.
Wappingers Falls	Dutchess	12	13	6	N.E.
Watertown	Jefferson	14	9	8	S.W.
Waverly	Tioga	8	13	10	N.W.-W.
Wedgewood	Schuyler	13	13	5	N.W.
Wells	Hamilton	15	9	7	W.
West Berne	Albany	11	9	11	W.
Westfield	Chautauqua	13	8	10	N.W.
Windham	Greene	11	13	7	W.

*Average for three years. †Average for two years.

Table VII gives statistics of the weather stations from which the weather data published in the preceeding tables are taken. All of the weather tables in this bulletin have been compiled from the published records of the Weather Bureau of the United States Department of Agriculture, excepting the data given for Geneva which come from records kept by this station.

TABLE VII.—STATISTICAL TABLE OF THE STATIONS FROM WHICH WEATHER DATA IS PUBLISHED IN THE PRECEDING TABLES.

STATION.	County.	Latitude. Degrees.	Latitude. Minutes.	Longitude. Degrees.	Longitude. Minutes.	Elevation in feet.	Region.
Addison	Steuben	42	7	77	16	1,000	Western plateau.
Albany	Albany	42	40	73	45	85	Hudson valley.
Alden	Erie	.....	.....	.....	.....	846	Western plateau.
Alfred	Allegany	42	15	77	55	1,824	Western plateau.
Angelica	Allegany	42	18	78	2	1,840	Western plateau.
Appleton	Niagara	43	20	78	41	330	Ontario shore.
Arcade	Wyoming	42	32	78	26	1,557	Western plateau.
Atlanta	Steuben	42	36	77	31	1,325	Central lakes.
Auburn	Cayuga	42	56	76	36	670	Central lakes.
Avon	Livingston	42	55	77	47	585	Central lakes.
Baldwinsville	Onondaga	43	11	76	21	390	Central lakes.
Bedford	Westchester	41	12	73	38	75	Hudson valley.
Binghamton	Broome	42	7	75	35	870	Eastern plateau.
Bolivar	Allegany	42	4	78	12	1,800	Western plateau.
Bouckville	Madison	42	53	75	34	1,350	Eastern plateau.
Brockport	Monroe	43	13	77	58	520	Ontario shore.
Buffalo	Erie	42	53	78	53	690	Erie shore.
Caldwell	Warren	.....	.....	.....	.....	350	Champlain valley.
Canajoharie	Montgomery	42	53	74	34	300	Mohawk valley
Canton	St. Lawrence	44	35	75	12	304	St. Lawrence valley.
Carmel	Putnam	41	25	73	40	500	Hudson valley.
Carvers Falls	Washington	.....	.....	.....	.....	243	Champlain valley.
Catskill	Greene	42	13	73	52	450	Hudson valley.
Cedar Hill	Albany	42	32	73	46	208	Hudson valley.
Cooperstown	Otsego	42	41	74	57	1,300	Eastern plateau.
Cortland	Cortland	42	36	76	13	1,120	Eastern plateau.
Cutchogue	Suffolk	.....	.....	.....	.....	32	Long Island.
Elba	Genesee	.....	.....	.....	.....	500	Western plateau.
Elmira	Chemung	42	6	76	56	863	Western plateau.
Fayetteville	Onondaga	43	1	76	2	530	Mohawk valley.
Franklinyille	Cattaraugus	42	20	78	29	1,598	Western plateau.
Geneva	Ontario	42	53	77	0	525	Central lakes.
Glens Falls	Warren	43	19	73	41	340	Champlain valley.
Gloversville	Fulton	43	3	74	22	802	Northern plateau.
Greenwich	Washington	43	6	76	.....	425	Hudson valley.
Griffin Corners	Delaware	.....	.....	.....	.....	2,260	Eastern plateau.

Hemlock Lake	Livingston	42	48	77	36	900	Central lakes.
Honeymead Brook	Dutchess	41	51	73	42	425	Hudson valley.
Humphrey	Cattaraugus	42	12	78	34	1,950	Western plateau.
Indian Lake	Hamilton	…	…	…	…	1,705	Northern plateau.
Ithaca	Tompkins	42	27	76	29	810	Central lakes.
Jamestown	Chautauqua	42	6	79	16	1,321	Western plateau.
Keene Valley	Essex	44	9	73	50	1,015	Champlain valley.
Liberty	Sullivan	41	46	74	46	1,467	Eastern plateau.
Little Falls	Herkimer	43	3	74	52	924	Mohawk valley.
Lockport	Niagara	43	10	78	45	600	Ontario shore.
Lowville	Lewis	43	47	75	30	900	Northern plateau.
Lyons	Wayne	43	6	77	0	407	Ontario shore.
Middletown	Orange	41	25	74	25	660	Eastern plateau.
Mohonk Lake	Ulster	41	47	74	10	1,235	Eastern plateau.
Moira	Franklin	…	…	…	…	200	Northern plateau.
New Lisbon	Otsego	42	35	75	13	1,234	Eastern plateau.
New York	New York	40	43	74	0	164	Long Island.
North Hammond	St. Lawrence	44	30	75	40	340	St. Lawrence valley.
Number Four	Lewis	43	50	75	12	1,571	Northern plateau.
Nunda	Livingston	42	53	77	59	1,336	Central lakes.
Ogdensburg	St. Lawrence	44	43	75	30	258	St. Lawrence valley.
Oneonta	Otsego	42	22	75	6	1,090	Eastern plateau.
Oswego	Oswego	43	29	76	35	304	Ontario shore.
Oxford	Chenango	42	23	75	40	1,000	Eastern plateau.
Oyster Bay	Nassau	…	…	…	…	40	Long Island.
Palermo	Oswego	43	24	76	20	460	Central lakes.
Penn Yan	Yates	42	39	77	5	758	Central lakes.
Perry City	Schuyler	42	33	76	44	1,038	Central lakes.
Plattsburg	Clinton	44	42	73	27	150	Champlain valley.
Port Jervis	Orange	41	21	74	40	470	Eastern plateau.
Potsdam	St. Lawrence	44	40	75	1	300	St. Lawrence valley.
Poughkeepsie	Dutchess	41	41	73	55	180	Hudson valley.
Primrose	Westchester	40	57	73	50	200	Hudson valley.
Richmondville	Schoharie	…	…	…	…	500	Mohawk valley.
Ridgeway	Orleans	43	16	78	25	…	Ontario shore.
Rochester	Monroe	43	8	77	42	621	Ontario shore.
Rome	Oneida	43	11	75	28	445	Mohawk valley.
Romulus	Seneca	42	43	76	57	719	Central lakes.
Saranac Lake	Franklin	44	8	74	19	1,550	Northern plateau.
Saratoga Springs	Saratoga	43	5	73	48	270	Mohawk valley.
Schenectady	Schenectady	42	49	73	57	246	Mohawk valley.
Setauket	Suffolk	40	57	73	5	40	Long Island.
Shortsville	Ontario	…	…	…	…	740	Central lakes.
Southampton	Suffolk	…	…	…	…	36	Long Island.
South Canisteo	Steuben	42	12	77	34	1,480	Western plateau.
South Kortright	Delaware	42	20	74	43	1,700	Eastern plateau.
South Schroon	Essex	…	…	…	…	1,225	Champlain valley.
Spier Falls	Saratoga	…	…	…	…	400	Hudson valley.

TABLE VII.— (*Continued*).

STATION.	County.	LATITUDE.		LONGITUDE.		Elevation in feet.	Region.
		Degrees.	Minutes.	Degrees.	Minutes.		
Straits' Corners	Tioga	42	9	76	25	600	Eastern plateau.
Syracuse	Onondaga	43	3	76	11	509	Mohawk valley.
Ticonderoga	Essex	43	51	72	25	344	Champlain valley.
Volusia	Chautauqua	....	....	....	....	1,167	Erie shore.
Wappingers Falls	Dutchess	41	35	73	55	110	Hudson valley.
Watertown	Jefferson	43	57	75	54	486	St. Lawrence valley.
Waverly	Tioga	42	1	76	34	825	Eastern plateau.
Wedgewood	Schuyler	42	25	76	56	1,350	Central lakes.
Wells	Hamilton	....	....	....	....	850	Northern plateau.
West Berne	Albany	42	37	74	10	600	Mohawk valley.
Westfield	Chautauqua	42	21	79	37	758	Erie shore.
Windham	Greene	....	....	....	....	1,520	Eastern plateau.

CHANGES IN CLIMATE.

There is a widespread belief that climate is permanently changeable in long periods. That is, that regions are becoming permanently hotter or colder, or wetter or dryer. If there are such changes, the matter becomes of intense interest to the horticulturist and the farmer; for a change in climate may force a change in horticultural or agricultural industries.

In the twenty-five year period we have been considering we have seen that there have been several seasons in succession of moisture and dryness, of cold and warmth, and of frostiness and lack of frost. The pendulum seems to swing first to the right and then to the left, but approximately as far in one direction as the other. Each tree generation, excepting, possibly, the peach, lives through one or possibly several of these oscillations. But are these changes permanent? Our retrospect of twenty-five years is not long enough to establish permanency in weather changes, but climatologists seem to be agreed in regard to the matter. And so, without taking space to give data or the views in full of those who have studied climatic changes, the general belief of climatologists in this regard may be summarized as follows:

It is well agreed that there have been climatic changes in the geological past; as periods of glaciers and periods of tropical heat in the latitude in which we live. Much evidence has been brought forward to show that there have been progressive and permanent changes in climate in the historic present. But such evidence when subjected to careful study has proved contradictory and unreliable, and it does not as yet seem to have been established that there are any considerable permanent changes in climate over large areas in historic times. It is now generally believed that periodic changes of climate are limited in time and not at all permanent. The causes of these periods of differing climate are generally ascribed to solar activity, but a satisfactory explanation of them has not yet been made. Neither the oscillations of climate nor the processes causing them are well understood. Contrary to popular belief, and possibly to former scientific belief, it is not now thought that man can greatly change climate by flooding or draining, by planting forests or by destroying forests, or in any way produce any important, long continued, or extended change in climate.

CONCLUSION.

Several facts have been made plain by this discussion of the relations of weather to the setting of fruit.

First, frosts, rain, cold weather and cold or high winds are the chief agencies in preventing the proper setting of fruit in New York.

Second, it is beyond the power of man to control weather except in the case of light frosts, which may be prevented to some extent if the proper precautions are taken.

Third, an abundance of sunshine and a low percentage of humidity give the most favorable conditions for the setting of fruit.

Fourth, locations for growing the different fruits should be selected with reference to general and local climate; in the first case, latitude, altitude and proximity to large bodies of water, are the determining factors, in the second case the lay of the land is the determinant.

Fifth, varieties of fruit of the several kinds can be selected with reference to time of blooming to escape in some degree injurious climatal agencies.

Sixth, fruits may be selected with reference to their ability, from one cause or another, to withstand injurious weather; of these, cultural treatment to induce strong vitality probably helps plants most to withstand stresses of harmful weather.

Seventh, the climate changes in short cycles but such oscillations are not permanent and it is probably beyond the power of man to change the climate by flooding or draining, by planting or destroying forests, or by any other means.

BLOOMING-TIME; WITH DATES OF BLOOMING FOR 866 VARIETIES OF FRUIT.

The life epochs of plants are of much importance to those who till the soil. Thus seeding-time, leafing-time, blooming-time, fruiting-time, mark the seasons for the agriculturist. These epochs are of particular importance to the orchardist, the welfare of the crop depending, oftentimes, upon the season and upon the weather in which they take place; orchard operations, too, are governed by them. The *time of blooming* is a particularly important period in growing fruits, and especially so as to the welfare of the crop.

Any knowledge, then, that will enable us to forecast the advent of the blooming season even though it be vague, must be helpful.

Blooming-time is not a fixed event in the succession of life events of plants. If, for example, we consider leafing and blooming we shall find that in the northern climates the tree fruits come into leaf and bloom almost simultaneously and at the first wave of summer weather. In more southern climates many of the varieties of the same species will bloom first and then come into foliage. Similarly, the relations as to time of taking place of all life-epochs are somewhat dependent upon climate and without doubt other conditions. Of the several attributes of climate, temperature seems to have by far the greatest influence in hastening or retarding the advent of blooming time.

Since temperature is so easily measured, and since plants may be observed under the different degrees of temperature, it would seem that there might be some thermal constant whereby the advance of vegetation can be gauged in any season. The problem is one that has engaged the attention of students of climate and plant life for nearly two centuries and is worth brief mention here.

Of the score or more of hypotheses that have been formed for paralleling the development of vegetation with thermometric values, the principal one is that of Hoffman.

Hoffman's[1] conclusion, after many years' study of the quantity of heat needed for a definite phase of vegetation was: That beginning with midwinter when vegetation is dormant, the zero point of vegetation in his hypothesis, and for which he takes the first of January as an arbitrary date, if one takes the sum of the daily, maximum, positive temperatures of a thermometer fully exposed to the sun, up to a day of the attainment of any definite phase of vegetation, as blooming, leafing, or ripe fruit, one has a thermal constant which will coincide from year to year to a satisfactory degree.

Relations that would follow from the above hypothesis are: Though a life epoch may begin at varying dates from year to year depending on the climate of the year, yet to reach a particular epoch, a plant requires an amount of heat that is constant from year to year. Plants may therefore be considered a means of measuring heat. The beginning of any life-epoch marks a certain

[1]Hoffman. Comparative phenological chart for Central Europe. *Petermann's Geog. Mitth.*, 1881.

sum total of heat up to that date; this sum total is the amount of heat required by the plant to reach the epoch in question.

It is probable that in our climate where temperature, of all the attributes of climate, pre-eminently influences vegetation, Hoffman's thermal constants can be used with some accuracy but only after long-continued observations in the locality in which they are to be used; for, beyond all question, plants will accommodate themselves to different sum totals of heat for their several life events in different localities.

If we seek for a more concrete guide than the thermal constant for forecasting the advent of blooming-time, we shall find even less satisfaction. The retreat of winter and the coming of spring are marked by the disappearance of snow, the breaking up of ice, the appearance of animals, the migration of birds and the putting-forth of vegetation. But all of these fail as reliable heralds of blooming-time. If we turn to the weather we shall find but little that is tangible, nothing that will guide predictions for more than a few days in advance. Blooming-time seems to follow a somewhat complicated series of weather changes, the chief features of which are a succession of hot and cold waves, the latter diminishing in frequency and force until the total amount of temperature for the season seems to force out the blossoms.

The physical features of a location have a marked effect on the blooming-time quite aside from the altitude and latitude which for most part govern temperature. Among the minor factors are proximity to large bodies of water; the slope of the land; the character of the soil; winds and wind-breaks. Plants bloom earlier in a sheltered valley, on a southern slope, or on a warm sandy soil, than on exposed plateaus, bleak hillsides, or heavy cold soils. The color of the wood, whether dark or light, may have a slight influence on the time of blooming.

With these brief considerations we pass to a discussion of the blooming dates of the apple, pear, peach, plum, cherry, apricot, nectarine and grape at this Station. Blooming dates are given for six years, from 1902 to 1907 inclusive for the tree fruits, and for the years 1892 to 1898 for the grape. For many years this Station has kept records of the blooming-time of the fruits grown. In 1902 an arrangement was made whereby such records were to be kept by the U. S. Department of Agriculture for the joint use of the Station and Department. The dates here given were taken for the first five years by H. P. Gould and the last year by W. F. Fletcher, both of the Department of Agriculture.

In making use of these dates, consideration must be given to the environment of the orchards at Geneva. The latitude at the Smith Astronomical Observatory, a quarter of a mile from the Station orchards, is 42° 52′ 46.2″; the altitude is from 500 to 525 feet above sea level; the soil is a stiff and rather cold clay; the orchard lies about a mile west of Seneca Lake, a body of water 40 miles in length and from 1 to 3½ miles in width and more than 600 feet deep. The lake has frozen over but a few times since the region was settled over a hundred years ago, and exercises a powerful influence on the adjacent country in lessening the cold of winter, the heat of summer, and in preventing early blooming.

The dates are those of the first open blossoms and of full bloom. They were taken from trees grown under normal conditions as to pruning, distance apart, and as to all other factors which might influence the blooming period. For most part the dates are from the same trees.

Special attention is called to the following deductions from the list of blooming dates:

Simultaneity of blooming.— It is evident that, if cross-fertilization is to play an important part in fruit-growing, in planting to secure it kinds must be chosen which come into blossom at the same time as those which they are expected to fertilize. This table shows the sorts that bloom together or nearly enough so to make cross-pollination possible. It will be found upon examining the list that, under normal conditions and during the average season, varieties of any one species overlap sufficiently for the above purpose unless it be the very early and very late varieties. Variations due to locality and to season must be expected but within the bounds of New York these will be slight. Properly interpreted the table of dates should be a useful guide as to the simultaneity of blooming.

Is the time of blooming correlated with the time of fruiting? — Many fruit growers consider that there is a correlation between the time of blooming and the time of ripening of fruits. Or, to put it in other words, they believe that early varieties bloom earlier than late ones and that late varieties are therefore less liable to have blossoms injured by late frosts. By selecting a large number of any of the several fruits for which blooming dates are given and by making a list from the fruit manuals of their period of ripening, one soon sees that there is absolutely no correlation between blooming and fruiting, although there are many ap-

parent exceptions. The writer has made a similar computation for leafing and fruiting and finds also that there is no correlation between these two life events.

How long are the several fruits in bloom? — It is often desirable to know how long varieties of fruits remain in bloom. The averages of the data for the five years considered in this Bulletin give this information: For apples as a species it is about 9 days; pears, 7 days; peaches, 8 days; plums, 7 days; cherries, 7 days; grapes, 10 days. The time from first blossoms until all have dropped varies in accordance with the factors we have discussed as affecting blooming time. In very hot, dry weather blossoms of some fruits do not last longer than forty-eight hours. Blossoms of the tree fruits, unlike those of many flowering plants, remain open day and night after they have once opened though pollination probably takes place during the day only.

In some seasons, or under some conditions, a few varieties of each of the several fruits have two sets of blossoms. When the trees of these varieties at such times are in full bloom unopened blossoms may be found. If the first blossoms are destroyed, the second set may set fruit. In case both sets produce crops there is an early and a late picking. Some varieties of cherries are remarkable for this double blossoming even in normal seasons.

The list shows early and late blooming varieties.— An inspection of the dates of blooming of all of the fruits shows that there is a variation of several days in most seasons between the appearance of the first blossoms of the different varieties. This can be taken advantage of in selecting sorts to avoid injury from frost.

The following varieties of apples, pears, peaches, plums and cherries are grouped as early or late bloomers. Averages were taken of the dates of bloom for six years with apples, and for five years with the remaining classes of fruit. The least difference in length of time between early and late bloomers was with peaches, and the varieties were more variable, some years blooming early and other years blooming late.

EARLY AND LATE BLOOMING VARIETIES OF FRUIT.

APPLES.

Early Bloomers.	*Late Bloomers.*
Bietigheimer	Ben Davis
Early Ripe	Northern Spy
Gravenstein	Peck *Pleasant*

APPLES — *Continued.*

Early Bloomers.	*Late Bloomers.*
Primate	Ralls
Paragon	Rome
Red Astrachan	Williams
Tompkins King	Yellow Newtown
Wagener	

CHERRIES.

Early Bloomers.	*Late Bloomers.*
Dikeman	Arch Duke
Downer	Brusseler Braune
Early Purple Guigne	English Morello
Luelling	Louis Philippe
Mercer	Montmorency
Napoleon Bigarreau	Montmorency Large
Rockport Bigarreau	
Windsor	

PEACHES.

Early Bloomers.	*Late Bloomers.*
Belle of Georgia	Foster
Early Rivers	Gibson Late
Frances	Globe
Gold Drop	Graves
Greensboro	Late Yellow
Summer Snow	Midseason Favorite
Waddell	Orleans
	Wager
	Wheatland

PEARS.

Early Bloomers	*Late Bloomers.*
Anjou	Japan Golden Russet
Flemish Beauty	Joan of Arc
Frederick Clapp	P. Barry
Garber	Shull
Japan	Sudduth
Le Conte	Winter Nelis
Mount Vernon	
Peffer	
Superfine	
Urbaniste	

PLUMS.

Early Bloomers.	*Late Bloomers.*
Abundance	Belle de September
Burbank	Damson Freestone
Climax	De Soto
Diamond	Forest Garden
Duane Purple	German Prune
Field	Golden Beauty
Georgeson	Hungarian Prune
Goliath	Milton
Normand	Minnesota
October Purple	Pond Seedling
White Kelsey	Pottawattamie
Wickson	Wild Goose
	Wolf
	Wyant

It is probable that early blooming varieties are not nearly so well cross-pollinated as the late blooming sorts; for there are always many blossoms on the early blooming sorts appearing late and until the late blooming kinds are in full bloom; and it is likely that pollen carried by insects maintains its viability for a considerable length of time making it available for the cross-pollination of the late blooming varieties. These factors, together with the fact that the weather is usually more propitious for the late blooming fruits, put the early flowering sorts at a great disadvantage in the matter of cross-pollination.

In Table VIII, giving blooming dates, the blooming-time of each variety is represented by a starred line following the name, each star representing a date. The first starred date represents the average date, for the number of observations given, of the first open blossoms. The starred line is extended two days beyond full bloom, this length of time being quite sufficient under average conditions to insure pollination. The varieties are arranged in order of their blooming. This arrangement of the blooming dates is adapted from Bulletin 6, Vol. XIII, of the Virginia Agricultural Experiment Station, by H. L. Price.

At the first glance it will be noted that the number of observations for the varieties of the several fruits differs. When the numbers are the same the years may have been different. This fact prevents an exact arrangement of the varieties in order of their

blooming. But it has been thought best to have the average time of blooming of each variety as accurate as possible to secure which as great a number of observations as could be had were necessarily used. Moreover, to have made the years of observation uniform in number and in years would have reduced the number of varieties greatly, since all of the varieties of a fruit do not often bloom the same year. However, a comparison of the blooming periods as shown in the table with the actual dates for the several years shows that the method of arrangement does not give a wide variance between the actual dates for any year and the average dates for the several years and that the blooming periods are therefore in practically their chronological order.

TABLE VIII.— DATES OF BLOOMING FOR 866 VARIETIES OF FRUITS.

PEACHES.

	No. of obser-vations.	May												
		5	6	7	8	9	10	11	12	13	14	15	16	17
Early Champion	3	*	*	*	*	*	*	*	*					
Early Charlotte	3	*	*	*	*	*	*	*						
Ford Choice	3	*	*	*	*	*	*	*						
Jennie Worthern	3	*	*	*	*	*	*	*						
Ostrander Late	3	*	*	*	*	*	*	*	*					
Potter	3	*	*	*	*	*	*	*	*	*	*	*		
Scruggs	3	*	*	*	*	*	*	*	*					
Stevens Rareripe	3	*	*	*	*	*	*	*	*					
Stump-the world	3	*	*	*	*	*	*	*						
Todd	3	*	*	*	*	*	*	*						
Waddell	4	*	*	*	*	*	*	*	*					
Wiard	3	*	*	*	*	*	*	*						
Atlanta	4		*	*	*	*	*	*	*	*				
Belle of Georgia	4		*	*	*	*	*	*	*	*				
Carman	3		*	*	*	*	*	*	*	*				
Cline No. 3	3		*	*	*	*	*	*						
Conkling	3		*	*	*	*	*	*	*					
Early Beauty	4		*	*	*	*	*	*	*					
Early Free	3		*	*	*	*	*	*						
Early Rivers	4		*	*	*	*	*	*	*	*				
Eureka	4		*	*	*	*	*	*	*	*				
Fitzgerald	3		*	*	*	*	*	*	*	*				
Frances	4		*	*	*	*	*	*	*					
G. and A	4		*	*	*	*	*	*	*	*	*			
Greensboro	4		*	*	*	*	*	*	*	*				
Hieley	4		*	*	*	*	*	*	*					
Lorentz	4		*	*	*	*	*	*	*	*	*			
Pratt	3		*	*	*	*	*	*	*	*				
Tornado	3		*	*	*	*	*	*	*					
Woodman Choice	3		*	*	*	*	*	*	*					
Beers Smock	4			*	*	*	*	*	*	*				
Bishop Early	4			*	*	*	*	*	*	*				
Capt. Eads	4			*	*	*	*	*	*	*	*			
Capt. Henry	3			*	*	*	*	*	*					
Champion	4			*	*	*	*	*	*	*				
Clifton Park	4			*	*	*	*	*	*	*				
Cline No. 2	4			*	*	*	*	*	*	*				

Crawford Late	4	*	*	*	*	*					
Crosby	4	*	*	*	*	*	*	*	*		
Dunn	4	*	*	*	*	*	*	*			
Elberta	4	*	*	*	*	*	*	*	*	*	
Floss	4	*	*	*	*	*	*	*	*	*	
Gold Drop	5	*	*	*	*	*	*	*	*		
Hyatt	4	*	*	*	*	*	*	*	*		
Lewis	5	*	*	*	*	*	*	*	*	*	*
Mammoth	4	*	*	*	*	*	*	*			
Midseason Favorite	4	*	*	*	*	*	*	*			
Mitchell	4	*	*	*	*	*	*	*	*		
North China No. 2	4	*	*	*	*	*	*	*	*	*	
Old Mixon Free	4	*	*	*	*	*	*	*			
Saint Marie	4	*	*	*	*	*	*	*	*	*	
Sea Eagle	4	*	*	*	*	*	*	*			
Sneed	5	*	*	*	*	*	*	*	*		
Smith Imperial	3	*	*	*	*	*	*	*			
Summer Snow	5	*	*	*	*	*	*	*	*	*	*
Wager	3	*	*	*	*	*	*	*	*	*	
Washington	4	*	*	*	*	*	*				
Yellow St. John	3	*	*	*	*	*	*	*	*		
Beach	4		*	*	*	*	*	*			
Bokara No. 3	5		*	*	*	*	*	*	*	*	
Cambrian	3		*	*	*	*	*	*	*	*	
Foster	4		*	*	*	*	*	*	*	*	
Gibson Late	3		*	*	*	*	*	*	*	*	
Kalamazoo	5		*	*	*	*	*	*	*	*	
Late Admirable	4		*	*	*	*	*	*			
Marcella	5		*	*	*	*	*	*	*	*	*
New Prolific	5		*	*	*	*	*	*	*	*	
Pride of Franklin	3		*	*	*	*	*	*	*	*	
Sargeant	5		*	*	*	*	*	*	*	*	
Ellison	5			*	*	*	*	*	*	*	

TABLE VIII — *Continued.*

CHERRIES.

	No. of observations.	May																	
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Early Purple Guigne	4	*	*	*	*	*	*												
Amarelle Bunt	5		*	*	*	*	*	*											
California Advance	5		*	*	*	*	*												
Centennial	5		*	*	*	*	*	*	*										
Dikeman	5		*	*	*	*	*	*	*										
Downer	5		*	*	*	*	*	*	*										
Hawley	5		*	*	*	*	*	*	*	*									
Luelling	5		*	*	*	*	*	*											
Mercer	5		*	*	*	*	*	*											
Mezel	5		*	*	*	*	*	*	*										
Napoleon Bigarreau	5		*	*	*	*	*	*											
Rockport Bigarreau	5		*	*	*	*	*	*	*	*									
Sparhawk Honey	5		*	*	*	*	*	*	*										
Yellow Spanish	5		*	*	*	*	*	*	*										
Bing	5			*	*	*	*	*	*										
Black Eagle	5			*	*	*	*	*	*	*	*								
Black Tartarian	5			*	*	*	*	*	*	*	*								
Black Tartarian Improved	5			*	*	*	*	*	*	*									
Cleveland	5			*	*	*	*	*	*	*									
Coe Transparent	5			*	*	*	*	*	*	*									
Elton	5			*	*	*	*	*	*	*	*								
Gov. Wood	5			*	*	*	*	*	*	*									
Ida	5			*	*	*	*	*	*	*									
Knight Early Red	5			*	*	*	*	*	*										
Napoleon	5			*	*	*	*	*	*	*	*								
Reine Hortense	5			*	*	*	*	*	*	*									
Schmidt Bigarreau	5			*	*	*	*	*	*	*	*	*	*						
Cerise de Ostheim	5				*	*	*	*	*	*	*	*	*						
Double Natte	5				*	*	*	*	*	*	*	*	*						
Dyehouse	4				*	*	*	*	*	*	*								
Hoke	5				*	*	*	*	*	*	*	*							
Kirtland	5				*	*	*	*	*	*	*	*	*						
May Duke	5				*	*	*	*	*	*	*								
Montmorency Ordinaire	5				*	*	*	*	*	*	*	*							
Rupp	5				*	*	*	*	*										
Stuart Biggarreau	5				*	*	*	*	*										
Windsor	5				*	*	*	*	*	*	*	*							

Arch Duke	5	*	*	*	*	*	*	*	*						
Auburn Duke	5	*	*	*	*	*	*	*	*						
Baldwin	5	*	*	*	*	*	*	*	*						
Early Richmond	5	*	*	*	*	*	*	*	*						
Esel Kirsche	5	*	*	*	*	*	*	*	*						
King Amarelle	5	*	*	*	*	*	*	*	*	*					
No. 9211	5	*	*	*	*	*	*	*	*						
Olivet	5	*	*	*	*	*	*	*	*						
Orel No. 23	5	*	*	*	*	*	*	*	*	*	*				
Royal Duke	5	*	*	*	*	*	*	*	*						
Sklanka	5	*	*	*	*	*	*	*	*	*					
Abesse d'Oignies	5		*	*	*	*	*	*	*	*					
Empress Eugenie	5		*	*	*	*	*	*	*	*	*	*			
George Glass	5		*	*	*	*	*	*	*						
Montmorency	5		*	*	*	*	*	*	*	*					
Montmorency, Large	5		*	*	*	*	*	*	*	*					
Brusseler Braune	5			*	*	*	*	*	*	*					
English Morello	5			*	*	*	*	*	*	*					
Heart Shape Weichsel	5			*	*	*	*	*	*	*	*	*			
Louis Phillipe	4			*	*	*	*	*	*	*					
Spate Amarelle	5			*	*	*	*	*	*	*	*	*	*		
Belle Magnifique	5					*	*	*	*	*	*	*	*	*	*
John Morris	5					*	*	*	*	*	*	*			

TABLE VIII — *Continued.*

PLUMS: DOMESTICA GROUP

(*Prunus domestica.*)

	No. of observations.	May. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
De Caradeuc	4				*	*	*	*	*																			
Orange	4					*	*	*	*	*	*																	
Tragedy Prime	3					*	*	*	*	*																		
Shipper	4						*	*	*	*	*	*	*	*														
St. Lawrence	3						*	*	*	*	*	*	*															
Tennant Prune	4						*	*	*	*	*	*																
Diamond	5							*	*	*	*	*	*															
Duane Purple	5							*	*	*	*	*	*	*														
Goliath	5							*	*	*	*	*	*															
Gueii	4							*	*	*	*	*	*															
Hector	5							*	*	*	*	*	*															
Imperial Gage	5							*	*	*	*	*	*															
Late Black Orleans	5							*	*	*	*	*	*	*														
Lombard	4							*	*	*	*	*	*															
Middleburg	5							*	*	*	*	*	*															
Monroe	3							*	*	*	*	*	*															
Prince Englebert	3							*	*	*	*	*	*															
Prince of Wales	3							*	*	*	*																	
Yellow Voronesh	5							*	*	*	*	*																
Arch Duke	5								*	*	*	*	*	*														
Bavay Green Gage	5								*	*	*	*	*	*														
Belgian Purple	4								*	*	*	*	*	*														
Bryanston	5								*	*	*	*	*															
Coe Golden Drop	5								*	*	*	*	*	*														
Copper	5								*	*	*	*	*	*														
Empire	5								*	*	*	*	*	*														
Field	5								*	*	*	*	*	*														
Frogmore Damson	4								*	*	*	*	*	*														
Guthrie Late	5								*	*	*	*	*	*														
Harriet	5								*	*	*	*	*	*														
Jefferson	4								*	*	*	*	*															
Lucomb Nonesuch	5								*	*	*	*	*															
Missouri Green Gage	5								*	*	*	*	*	*														
Ottoman Seedling	4								*	*	*	*	*	*														
Pringle Blue	5								*	*	*	*	?															

Saunders	4	*	*	*	*	*	*					
Spaulding	4	*	*	*	*	*	*					
Stanton	4	*	*	*	*	*	*					
Tennant	5	*	*	*	*	*						
Transparent	5	*	*	*	*	*	*	*				
Warner Late Red	5	*	*	*	*	*	*	*				
Washington	5	*	*	*	*	*	*	*				
White Nicholas	5	*	*	*	*	*	*					
Yellow Gage	4	*	*	*	*	*	*					
Autumn Compote	5		*	*	*	*	*	*				
Bradshaw	4		*	*	*	*	*	*	*			
Clingstem	5		*	*	*	*	*	*				
Count Altham	4		*	*	*	*	*	*	*	*		
Czar	5		*	*	*	*	*	*				
Dame Aubert	5		*	*	*	*	*	*				
Clyman	5		*	*	*	*	*	*				
Early Orange	5		*	*	*	*	*	*				
Gen. Hand	5		*	*	*	*	*	*	*			
King of Damsons	5		*	*	*	*	*	*				
Kirke	5		*	*	*	*	*	*				
McLaughlin	5		*	*	*	*	*					
Mefunka	5		*	*	*	*	*					
Moldavka	5		*	*	*	*	*	*				
Monarch	5		*	*	*	*	*	*	*			
Moore Arctic	5		*	*	*	*	*	*	*			
Mottled Prune	5		*	*	*	*	*	*	*			
Newark	5		*	*	*	*	*	*	*	*		
Peter Yellow Gage	5		*	*	*	*	*	*	*			
Pringle Purple	5		*	*	*	*	*					
Prune d'Agen	5		*	*	*	*	*	*	*	*		
Royal Hative	5		*	*	*	*	*	*	*			
Saratoga	5		*	*	*	*	*					
Sheldrake	5		*	*	*	*	*	*				
Shipper Pride	5		*	*	*	*	*	*	*			
Smith Orleans	5		*	*	*	*	*	*	*			
Stark Green Gage	4		*	*	*	*	*	*				
Sweet Damson	5		*	*	*	*	*	*	*			
Transparent Gage	5		*	*	*	*	*	*	*			
Union Purple	5		*	*	*	*	*					
Victoria	5		*	*	*	*	*					
Wyzerka	5		*	*	*	*	*	*	*			
Yellow Egg	5		*	*	*	*	*	*				
Crittenden Damson	5			*	*	*	*	*	*	*		
Early Rivers	5			*	*	*	*	*				
Giant Prune	4			*	*	*	*	*	*			
Grand Duke	4			*	*	*	*	*	*	*	*	*
Hudson River	5			*	*	*	*	*	*			
Ickworth Imperatrice	5			*	*	*	*	*	*	*	*	*

TABLE VIII — *Continued.*

PLUMS.

	No. of observations.	May. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Italian Prune	4										*	*	*	*	*	*	*											
Lafayette	5										*	*	*	*	*	*	*											
Miller Superb	5										*	*	*	*	*	*	*											
Mogul	5										*	*	*	*	*	*												
Pacific Prune	5										*	*	*	*	*													
Palatine	5										*	*	*	*	*	*												
Pearl	5										*	*	*	*	*	*												
Quackenboss	5										*	*	*	*	*	*	*											
Shropshire Damson	5										*	*	*	*	*	*	*	*	*									
Tobias Gage	5										*	*	*	*	*	*	*											
Ungarish Prune	5										*	*	*	*	*	*	*											
Barbo de Anti	5											*	*	*	*	*	*	*										
Black Bullace	5											*	*	*	*	*	*	*										
Bouloff	5											*	*	*	*	*	*											
Clarice Mammoth	5											*	*	*	*	*	*	*	*									
French Damson	5											*	*	*	*	*	*											
Hungarian	4											*	*	*	*	*	*	*										
Niagara	3											*	*	*	*	*	*	*										
Sugar Prune	4											*	*	*	*	*	*											
Wangenheim	5											*	*	*	*	*	*											
Belle de September	5												*	*	*	*	*	*	*									
Darwin Peach	4												*	*	*	*	*											
German Prune	5												*	*	*	*	*	*										
Golden Gage	3												*	*	*	*	*	*										
Pacific	5												*	*	*	*	*	*										
Pond Seedling	5												*	*	*	*	*	*	*									
Purple Gage	5												*	*	*	*	*	*										
Reine Claude Tardive de Chambourcy	3												*	*	*	*	*	*	*									
Weedsport German Prune	5												*	*	*	*	*	*										
York State Prune	5												*	*	*	*	*	*										
Freestone Damson	5													*	*	*	*	*	*	*	*							
Jaune d' Agen	3													*	*	*	*	*	*									
Damson Freestone	5														*	*	*	*	*	*	*							
Latz: German Prune	3														*	*	*	*	*	*								
Poole Pride	4															*	*	*	*	*	*							

		PLUMS: JAPANESE GROUP. (*Prunus triflora.*)																
Georgeson	4	*	*	*	*	*	*	*										
Shiro Somono	4	*	*	*	*	*	*	*										
Abundance	5		*	*	*	*	*	*	*									
Botan	4		*	*	*	*	*	*	*									
Hattankio	4		*	*	*	*	*	*										
Normand	3		*	*	*	*	*	*										
Paragon	3		*	*	*	*	*	*	*	*	*							
Red June	5		*	*	*	*	*	*										
Yosebe	5		*	*	*	*	*	*										
Burbank	4		*	*	*	*	*											
Engre	5			*	*	*	*	*	*	*								
Long Fruit	5			*	*	*	*	*	*									
Maru	5			*	*	*	*	*	*	*								
October Purple	5			*	*	*	*	*	*	*								
Ogon	5			*	*	*	*	*	*									
True Sweet Botan	5			*	*	*	*	*	*									
White Kelsey	5			*	*	*	*	*	*	*								
Yeddo	4			*	*	*	*	*	*	*								
Chabot	5				*	*	*	*	*	*	*							
Eagle	4				*	*	*	*	*	*	*	*						
Mikado	5				*	*	*	*	*	*								
Wickson	5				*	*	*	*	*	*								
Orient	5					*	*	*	*	*	*	*						
Uchi Beni	5					*	*		*	*	*	*						
		PLUMS: AMERICANA GROUP. (*Prunus americana.*)																
Marcus	4				*	*	*	*	*	*	*							
Ocheeda	4				*	*	*	*	*	*	*							
Champion	5					*	*	*	*	*	*	*						
New Ulm	4					*	*	*	*	*	*	*	*					
Pilot	5					*	*	*	*	*	*							
Hawkeye	4						*	*	*	*	*	*	*					
Wood	5						*	*	*	*	*	*						
California Seedling	5							*	*	*	*	*	*	*	*	*	*	
De Soto	5							*	*	*	*	*	*	*				
Gold	5							*	*	*	*	*	*	*	*			
Hammer	4							*	*	*	*	*	*	*	*	*	*	
Baker	5								*	*	*	*	*					
Forest Garden	5								*	*	*	*	*	*	*	*	*	*
Wolf	5								*	*	*	*	*	*				
Wyant	4								*	*	*	*	*	*	*	*	*	
		PLUMS: NIGRA GROUP. (*Prunus americana Nigra.*)																
Aitken	5			*	*	*	*	*	*									
Cheney	4				*	*	*	*	*	*	*							

TABLE VIII — *Continued.*

PLUMS.

	No. of observations.	May.																										
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
HYBRID PLUMS.																												
Climax	4						*	*	*	*	*	*	*															
Bartlett	4							*	*	*	*	*	*	*	*													
Chalco	4								*	*	*	*	*	*	*	*												
Sultan	4								*	*	*	*	*	*	*	*												
Mariana	5									*	*	*	*	*	*	*	*											
America	5									*	*	*	*	*	*	*	*	*	*	*								
Ames	5										*	*	*	*	*	*	*											
Juicy	5												*	*	*	*	*	*	*									
PLUMS: CHICKASAW GROUP. (*Prunus angustifolia*).																												
Robinson	3												*	*	*	*	*	*	*									
Askansas	5													*	*	*	*	*	*	*	*							
Newman	4													*	*	*	*	*	*	*	*							
Pottawattamie	4														*	*	*	*	*	*	*	*	*	*				
PLUMS: HORTULANA GROUP. (*Prunus hortulana*).																												
Chas. Downing	4													*	*	*	*	*	*	*	*							
Milton	5														*	*	*	*	*	*								
Wild Goose	5														*	*	*	*	*	*	*	*						
Sophie	5															*	*	*	*	*	*	*						
PLUMS: WAYLAND GROUP. (*Prunus hortulana*).																												
Golden Beauty	4															*	*	*	*	*	*	*						
World Beater	5															*	*	*	*	*	*	*	*	*				
Missouri Apricot	5																*	*	*	*	*	*	*	*	*			
Wayland	3																*	*	*	*	*	*	*	*	*	*	*	*
PLUMS: MINER GROUP. (*Prunus hortulana*).																												
Surprise	5											*	*	*	*	*	*	*	*									
Oren	4														*	*	*	*	*	*	*							
Maquoketa	5															*	*	*	*	*	*	*	*	*	*			
PLUMS: SIMON GROUP. (*Prunus simonii*).																												
Prunus Simoni	3					*	*	*	*	*	*																	

TABLE VIII — *Continued.*

PEARS.

	No. of observations.	May.															
		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Japan	3	*	*	*	*	*	*	*									
Cincincis	3		*	*	*	*	*	*	*	*	*	*					
Diamyo	4		*	*	*	*	*	*	*								
Ellis	4		*	*	*	*	*	*	*								
Sloyer	4		*	*	*	*	*	*	*	*	*						
Anjou	5			*	*	*	*	*	*	*							
Bessimianka	4			*	*	*	*	*	*								
Comice	5			*	*	*	*	*	*	*							
Dewey	5			*	*	*	*	*	*	*	*						
Directeur Alphande	4			*	*	*	*	*	*	*							
Dorset	5			*	*	*	*	*	*								
Doyenne Guillard	5			*	*	*	*	*	*	*	*						
Dr. Hoskins	3			*	*	*	*	*	*								
E. No. 47 *Jones*	5			*	*	*	*	*	*	*							
Flemish Beauty	4			*	*	*	*	*	*								
Garber	5			*	*	*	*	*	*	*	*						
Howell	4			*	*	*	*	*	*								
Le Conte	5			*	*	*	*	*	*	*	*						
Madame Treyve	5			*	*	*	*	*	*	*							
Mongolian Snow	5			*	*	*	*	*	*	*	*						
Osband Summer	3			*	*	*	*	*	*								
Pres. Drouard	4			*	*	*	*	*	*								
Rutter	4			*	*	*	*	*	*	*							
Urbaniste	4			*	*	*	*	*	*								
Vicar of Wakefield	3			*	*	*	*	*	*	*							
W. 23	4			*	*	*	*	*	*								
Ananas d'Ete	4				*	*	*	*	*	*	*						
Angouleme	5				*	*	*	*	*	*	*	*					
Buffum	5				*	*	*	*	*	*							
Cocklin	5				*	*	*	*	*	*	*	*					
Conferance	4				*	*	*	*	*	*							
Craig	5				*	*	*	*	*	*							
Dana Hovey	4				*	*	*	*	*	*	*						
Delices de Louvenjal	5				*	*	*	*	*	*	*						
Ellwanger	5				*	*	*	*	*	*	*						
Flax	4				*	*	*	*	*	*	*						
Gansel Seckel	5				*	*	*	*	*	*	*						

TABLE VIII — *Continued.*

PEARS.

	No. of observations.	May. 8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Grand Isle	5				*	*	*	*	*	*	*	*					
Jones	5				*	*	*	*	*	*	*						
Lawson	5				*	*	*	*	*	*	*	*					
Longworth No. 1	5				*	*	*	*	*	*							
Mount Vernon	5				*	*	*	*	*	*							
Nickerson	5				*	*	*	*	*								
Oliver des Serres	4				*	*	*	*	*	*	*						
Pierre Tourasse	3				*	*	*	*	*								
Slutsk	5				*	*	*	*	*	*	*						
Stout	3				*	*	*	*	*	*							
Summer Beauty	4				*	*	*	*	*	*							
Victor	4				*	*	*	*	*	*							
Ansault	5					*	*	*	*	*	*	*					
Clapp Favorite	4					*	*	*	*	*	*						
Duchess	4					*	*	*	*	*	*	*					
Easter Beurre	5					*	*	*	*	*	*	*	*	*			
Fitzwater	5					*	*	*	*	*	*	*	*				
Louise	5					*	*	*	*	*	*	*	*				
Manning Elizabeth	4					*	*	*	*	*	*	*	*				
Pitmaston Duchess	3					*	*	*	*	*	*						
Pound	4					*	*	*	*	*	*	*					
Raymond de Montlaur	5					*	*	*	*	*	*	*					
St. Ghislain	3					*	*	*	*	*	*	*					
Theresa Appert	5					*	*	*	*	*	*	*					
Assomption	4						*	*	*	*	*	*					
B. S. Fox	4						*	*	*	*	*	*	*				
Congress	3						*	*	*	*	*	*					
De Lacroix	3						*	*	*	*	*	*	*				
Frederick Clapp	4						*	*	*	*	*	*	*	*			
Gans	3						*	*	*	*	*	*	*				
Idaho	3						*	*	*	*	*	*	*	*			
Lawrence	3						*	*	*	*	*						
Madame von Siebold	3						*	*	*	*	*	*					
Marguerite Marillat	3						*	*	*	*	*	*					
Maurice Desportes	5						*	*	*	*	*	*	*				
Peffer	4						*	*	*	*	*	*					
Reeder (Dr.)	3						*	*	*	*	*	*	*	*	*		

Seckel	4	*	*	*	*	*	*	*						
Superfin	4	*	*	*	*	*	*	*	*					
Ulm	5	*	*	*	*	*	*	*						
Clairgeau	4		*	*	*	*	*	*						
Dempsey	4		*	*	*	*	*	*						
Fondante de Bihorel	4		*	*	*	*	*	*	*					
Japan Golden Russet	4		*	*	*	*	*	*	*	*				
Joan of Arc	4		*	*	*	*	*	*	*	*				
Josephine de Malines	4		*	*	*	*	*	*	*					
Liegel	5		*	*	*	*	*	*						
Lucy Duke	4		*	*	*	*	*	*	*	*				
Lucrative	3		*	*	*	*	*	*						
Ritson	3		*	*	*	*	*	*	*	*				
Sheldon	4		*	*	*	*	*	*	*					
Winter Nelis	3		*	*	*	*	*	*	*	*				
Bordeaux	3			*	*	*	*	*	*	*	*			
Lincoln	3			*	*	*	*	*						
P. Barry	4			*	*	*	*	*	*	*	*	*		
Vermont Beauty	3			*	*	*	*	*	*	*	*			
Alamo	4				*	*	*	*	*	*	*	*	*	*
Seneca	4				*	*	*	*	*	*	*	*	*	
Sudduth	3						*	*	*	*	*	*	*	*

TABLE VIII — *Continued.*

APPLES.

	No. of obser-vations.	May.																			
		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Gideon No. 7	3	*	*	*	*	*	*	*	*	*	*	*	*								
Longfield	4	*	*	*	*	*	*	*	*	*	*	*	*								
Breskovka	6		*	*	*	*	*	*	*	*											
Dudley	5		*	*	*	*	*	*	*	*											
Gravenstein	6		*	*	*	*	*	*	*	*	*	*									
Kittageskee	6		*	*	*	*	*	*	*	*	*										
Aport Orient	3			*	*	*	*	*	*	*	*	*	*								
Avery	3			*	*	*	*	*	*												
Berkoff	3			*	*	*	*	*	*	*	*	*	*								
Bietigheimer	6			*	*	*	*	*	*	*	*	*									
Blushed Calville	4			*	*	*	*	*	*	*	*	*	*								
Boskoop	3			*	*	*	*	*	*	*	*	*	*	*							
Charlamoff	5			*	*	*	*	*	*	*	*	*									
Charlock Reinette	6			*	*	*	*	*	*	*	*										
Dartmouth	4			*	*	*	*	*	*	*	*	*									
Early Ripe	6			*	*	*	*	*	*	*	*	*									
Jefferis	6			*	*	*	*	*	*	*	*	*	*								
Landsberg	3			*	*	*	*	*	*	*	*	*	*								
Late Duchess	5			*	*	*	*	*	*	*	*	*	*								
Ostrakoff	5			*	*	*	*	*	*	*	*	*	*								
Patten	6			*	*	*	*	*	*	*	*	*	*								
Paul Imperial	6			*	*	*	*	*	*	*	*	*									
Primate	6			*	*	*	*	*	*	*	*	*									
Reinette Pippin	5			*	*	*	*	*	*	*	*	*									
Rutledge	6			*	*	*	*	*	*	*	*	*	*								
Sandbrook	4			*	*	*	*	*	*	*	*	*	*	*							
Smokehouse	6			*	*	*	*	*	*	*	*	*	*								
Sops of Wine	5			*	*	*	*	*	*	*	*	*	*								
Stark	3			*	*	*	*	*	*	*	*	*	*	*							
Striped Fameuse	4			*	*	*	*	*	*	*	*	*	*	*							
Tetofsky	3			*	*	*	*	*	*	*	*	*									
Vineuse Rouge	3			*	*	*	*	*	*	*	*	*									
Wheeler No. 4	3			*	*	*	*	*	*	*	*	*	*	*							
Windsor	6			*	*	*	*	*	*	*	*	*									
Amassia	6				*	*	*	*	*	*	*		*								
Arkansas	6				*	*	*	*	*	*	*	*	*	*							
Arkansas Black	5				*	*	*	*	*	*	*	*	*	*							
Baxter	6				*	*	*	*	*	*	*	*	*	*							

Benninger	6	*	*	*	*	*	*	*	*	*			
Benoni	4	*	*	*	*	*	*	*	*	*			
Chenango	5	*	*	*	*	*	*	*	*	*			
Currant	4	*	*	*	*	*	*	*					
Early Joe	5	*	*	*	*	*	*	*	*	*			
Excelsior	5	*	*	*	*	*	*	*	*	*	*		
Fameuse No. 1	6	*	*	*	*	*	*	*	*	*			
Gideon	6	*	*	*	*	*	*	*	*	*	*		
Golden Russet	6	*	*	*	*	*	*	*	*	*	*		
Howard Best	5	*	*	*	*	*	*	*	*				
Hurlbut	5	*	*	*	*	*	*	*	*	*	*		
Kalkidon	8	*	*	*	*	*	*	*	*	*	*		
Keswick	6	*	*	*	*	*	*	*	*				
Lead	6	*	*	*	*	*	*	*	*	*			
Lou	5	*	*	*	*	*	*	*	*	*	*		
McIntosh	6	*	*	*	*	*	*	*	*	*			
Maiden Blush	6	*	*	*	*	*	*	*	*	*	*		
Mann	6	*	*	*	*	*	*	*	*	*	*		
Martha	6	*	*	*	*	*	*	*	*	*	*		
Mellott	6	*	*	*	*	*	*	*	*	*			
Milwaukee	6	*	*	*	*	*	*	*	*	*			
Mountain Sweet	6	*	*	*	*	*	*	*	*				
Munson	6	*	*	*	*	*	*	*	*	*	*		
Nelson	6	*	*	*	*	*	*	*	*	*			
New Water	5	*	*	*	*	*	*	*	*	*			
Oldenburg	5	*	*	*	*	*	*	*	*	*	*		
Paragon	6	*	*	*	*	*	*	*					
Parry White	5	*	*	*	*	*	*	*	*	*	*		
Pease	8	*	*	*	*	*	*	*	*	*	*	*	
Pomme Grise	6	*	*	*	*	*	*	*	*	*	*		
Prince Rudolph Imperial	8	*	*	*	*	*	*	*					
Schodack	5	*	*	*	*	*	*	*					
September	6	*	*	*	*	*	*	*	*	*			
Salome	8	*	*	*	*	*	*	*	*	*			
Stuart Golden	8	*	*	*	*	*	*	*	*	*	*	*	
Tompkins King	6	*	*	*	*	*	*	*	*	*	*	*	
Twenty Ounce	5	*	*	*	*	*	*	*	*				
Vochin Crimean	3	*	*	*	*	*	*	*	*	*	*	*	
Wagener	6	*	*	*	*	*	*	*	*	*			
Washington Strawberry	6	*	*	*	*	*	*	*	*	*	*		
Wheeler No. 27	4	*	*	*	*	*	*	*	*	*	*		
Whitney	8	*	*	*	*	*	*	*	*	*			
Winter Golden Sweet	6	*	*	*	*	*	*	*	*	*			
Yellow Transparent	3	*	*	*	*	*	*	*	*	*			
American Best	5		*	*	*	*	*	*	*	*	*		
Arabskoe	4		*	*	*	*	*	*	*	*	*	*	
Batullen	5		*	*	*	*	*	*	*	*	*	*	*
Bellborodooskoe	6		*	*	*	*	*	*	*	*			

TABLE VIII — *Continued.*

APPLES.

	No. of observations.	May. 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Canada Baldwin	6					*	*	*	*	*	*	*	*	*							
Canada Reinette	5					*	*	*	*	*	*	*	*	*							
Dickinson	5					*	*	*	*	*	*	*	*	*							
Dutch Mignonne	5					*	*	*	*	*	*	*	*								
Esopus *Spitzenburg*	6					*	*	*	*	*	*	*	*	*	*						
Everbearing	4					*	*	*	*	*	*	*	*								
Fall Pippin	6					*	*	*	*	*	*	*	*	*	*						
Fanny	6					*	*	*	*	*	*	*	*								
Florence	6					*	*	*	*	*	*	*	*	*	*						
Gimmersta	6					*	*	*	*	*	*	*	*	*							
Gladstone	4					*	*	*	*	*	*	*	*	*	*	*					
Golden Reinette	3					*	*	*	*	*	*	*	*								
Great Mogul	6					*	*	*	*	*	*	*	*	*							
Haas	6					*	*	*	*	*	*	*	*	*							
Haskel	3					*	*	*	*	*	*	*	*	*							
Hazen	4					*	*	*	*	*	*	*	*	*	*						
Holland Winter	5					*	*	*	*	*	*	*	*	*							
Jacobs Sweet	4					*	*	*	*	*	*	*	*	*	*						
Jarvis	6					*	*	*	*	*	*	*	*	*							
Jersey Sweet	6					*	*	*	*	*	*	*	*	*							
Judson	5					*	*	*	*	*	*	*	*	*							
Louise	6					*	*	*	*	*	*	*	*	*	*						
Magog	6					*	*	*	*	*	*	*	*	*							
Manwaring	6					*	*	*	*	*	*	*	*	*	*						
Milden	4					*	*	*	*	*	*	*	*	*	*						
Monmouth	6					*	*	*	*	*	*	*	*	*							
Monroe	6					*	*	*	*	*	*	*	*								
Moore Sweet	4					*	*	*	*	*	*	*	*	*	*	*					
Mosher	6					*	*	*	*	*	*	*	*								
Parlin	5					*	*	*	*	*	*	*	*	*							
Peach	3					*	*	*	*	*	*	*	*	*	*						
Pewaukee	6					*	*	*	*	*	*	*	*	*							
Pumpkin Russet	6					*	*	*	*	*	*	*	*	*	*						
Red Canada	5					*	*	*	*	*	*	*	*	*							
R. I. *Greening*	6					*	*	*	*	*	*	*	*	*	*						
Roxbury	6					*	*	*	*	*	*	*	*	*	*						
Scott	5					*	*	*	*	*	*	*	*								

Shirley	6	*	*	*	*	*	*	*	*	*			
Shull	6	*	*	*	*	*	*	*	*	*			
Stayman Winesap	6	*	*	*	*	*	*	*	*	*	*		
Streaked Pippin	5	*	*	*	*	*	*	*	*				
Swaar	3	*	*	*	*	*	*	*	*	*			
Sylvester	5	*	*	*	*	*	*	*	*	*	*		
Thompson	3	*	*	*	*	*	*	*	*	*	*		
Titus Pippin	6	*	*	*	*	*	*	*	*	*			
Tufts	4	*	*	*	*	*	*	*	*	*			
Wabash Red	5	*	*	*	*	*	*	*	*	*	*		
Wandering Spy	5	*	*	*	*	*	*	*	*	*			
Wheeler No. 7	3	*	*	*	*	*	*	*	*	*			
Wheeler No. 17	4	*	*	*	*	*	*	*	*	*			
Wheeler No. 31	4	*	*	*	*	*	*	*	*	*	*		
White Pippin	6	*	*	*	*	*	*	*	*				
Winterstein	5	*	*	*	*	*	*	*	*				
Alexander	6		*	*	*	*	*	*	*	*	*		
Autumn Streaked	3		*	*	*	*	*	*	*	*	*	*	*
Baldwin	6		*	*	*	*	*	*	*	*	*		
Bismark	3		*	*	*	*	*	*	*	*	*		
Bogdanoff Glass	6		*	*	*	*	*	*	*	*	*		
Boys delight	4		*	*	*	*	*	*	*	*	*	*	
Cherry Red	3		*	*	*	*	*	*	*	*	*	*	*
Clayton	4		*	*	*	*	*	*	*	*	*	*	
Deacon Jones	6		*	*	*	*	*	*	*	*			
Ewalt	6		*	*	*	*	*	*	*	*			
Ferdinand	6		*	*	*	*	*	*	*	*	*	*	
Fishkill	6		*	*	*	*	*	*	*	*			
Gano	6		*	*	*	*	*	*	*	*	*		
Gideon Sweet	5		*	*	*	*	*	*	*	*	*		
Grandmother	6		*	*	*	*	*	*	*	*			
Grimes	5		*	*	*	*	*	*	*	*	*		
Grosh	5		*	*	*	*	*	*	*	*	*	*	
Hyslop	5		*	*	*	*	*	*	*	*	*		
Jewett Red	5		*	*	*	*	*	*	*	*	*	*	
Lady Sweet	5		*	*	*	*	*	*	*	*			
Landon	6		*	*	*	*	*	*	*	*			
Lankford	5		*	*	*	*	*	*	*	*	*	*	
Lord	4		*	*	*	*	*	*	*	*	*		
Marigold	6		*	*	*	*	*	*	*	*	*		
Morse	4		*	*	*	*	*	*	*	*	*		
Mother	6		*	*	*	*	*	*	*	*	*	*	*
Nero	4		*	*	*	*	*	*	*	*	*	*	*
Newtown Spitzenburg	6		*	*	*	*	*	*	*	*	*	*	*
Ohio Pippin	6		*	*	*	*	*	*	*	*			
Okabena	5		*	*	*	*	*	*	*	*	*		
Peter	4		*	*	*	*	*	*	*	*	*		
Pickard Reserve	4		*	*	*	*	*	*	*	*	*		

TABLE VIII — *Continued.*

APPLES.

	No. of obser-vations.	May. 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Picta Striata	6						*	*	*	*	*	*	*	*							
Pumpkin Sweet	6						*	*	*	*	*	*	*	*	*						
Safstaholms	5						*	*	*	*	*	*	*	*							
Sandy Glass	6						*	*	*	*	*	*	*	*							
Shannon	6						*	*	*	*	*	*	*	*	*						
Sigfried	5						*	*	*	*	*	*	*	*	*	*					
Skelton	3						*	*	*	*	*	*	*	*	*	*	*				
Sutton	6						*	*	*	*	*	*	*	*	*						
Switser	3						*	*	*	*	*	*	*	*	*						
Thompson No. 39	6						*	*	*	*	*	*	*	*							
Walker Beauty	6						*	*	*	*	*	*	*	*	*						
Wallace Howard	6						*	*	*	*	*	*	*	*	*						
Water	3						*	*	*	*	*	*	*	*	*	*					
Western Beauty	6						*	*	*	*	*	*	*	*	*						
Williams	6						*	*	*	*	*	*	*	*	*	*					
Wolf River	5						*	*	*	*	*	*	*	*	*						
York Imperial	4						*	*	*	*	*	*	*	*	*	*	*	*			
Akin	6							*	*	*	*	*	*	*							
Allison	3							*	*	*	*	*	*	*	*	*	*	*			
American Codling	3							*	*	*	*	*	*	*	*	*	*				
Beauty of Bath	3							*	*	*	*	*	*	*	*	*	*	*			
Ben Davis	6							*	*	*	*	*	*	*	*	*	*				
Blushing Bride	3							*	*	*	*	*	*	*	*	*	*	*			
Boiken	3							*	*	*	*	*	*	*	*	*					
Centennial	5							*	*	*	*	*	*	*	*	*					
Champlain	5							*	*	*	*	*	*	*	*	*	*				
Colvert	6							*	*	*	*	*	*	*	*	*	*	*			
Donn Marie	3							*	*	*	*	*	*	*	*	*	*				
Doctor	5							*	*	*	*	*	*	*	*	*	*				
Riser	5							*	*	*	*	*	*	*	*	*					
Givens	4							*	*	*	*	*	*	*	*	*					
Golden Pearmain	3							*	*	*	*	*	*	*	*	*					
Golden Sweet	3							*	*	*	*	*	*	*	*	*	*				
Green Newtown	5							*	*	*	*	*	*	*	*						
Hubbardston	6							*	*	*	*	*	*	*	*	*					
Jersey Blue	3							*	*	*	*	*	*	*	*	*	*				
Jonathan	6							*	*	*	*	*	*	*	*	*					

Jonathan Buler	6	*	*	*	*	*	*	*	*				
Mammoth	3	*	*	*	*	*	*	*	*	*			
Northern Spy	6	*	*	*	*	*	*	*	*	*			
Old Garden	5	*	*	*	*	*	*	*	*	*	*		
Peck *Pleasant*	6	*	*	*	*	*	*	*	*	*	*		
Princess Wilhelma von Prussen	3	*	*	*	*	*	*	*	*	*			
Queen	3	*	*	*	*	*	*	*	*	*	*	*	
Ramsdell Sweet	3	*	*	*	*	*	*	*	*	*			
Red Astrachan	3	*	*	*	*	*	*	*	*				
Red Statiner	3	*	*	*	*	*	*	*	*	*	*	*	
Shackleford	6	*	*	*	*	*	*	*	*				
Sheddan	3	*	*	*	*	*	*	*	*	*			
Skruichappel	3	*	*	*	*	*	*	*	*	*	*	*	
Springdale	4	*	*	*	*	*	*	*	*	*	*	*	
Starkey	3	*	*	*	*	*	*	*	*	*	*		
Swenker	3	*	*	*	*	*	*	*	*	*	*		
Tolman Sweet	5	*	*	*	*	*	*	*	*	*	*		
Wealthy	5	*	*	*	*	*	*	*	*	*	*		
Wheeler No. 8	3	*	*	*	*	*	*	*	*	*			
Wheeler No. 14	3	*	*	*	*	*	*	*	*	*			
Wheeler No. 56	3	*	*	*	*	*	*	*	*	*			
Wheeler No. 64	3	*	*	*	*	*	*	*	*	*			
Brown	3		*	*	*	*	*	*	*	*	*	*	*
Challenger	3		*	*	*	*	*	*	*	*	*	*	*
Collins	3		*	*	*	*	*	*	*	*	*	*	*
Dickey	4		*	*	*	*	*	*	*	*	*		
Eicke	5		*	*	*	*	*	*	*	*			
Golden Nonpareille	5		*	*	*	*	*	*	*	*			
Hurne	3		*	*	*	*	*	*	*	*	*	*	*
Lombard	4		*	*	*	*	*	*	*	*	*	*	
Lord Seeding	4		*	*	*	*	*	*	*				
Perry	3		*	*	*	*	*	*	*	*			
Pyrus Coronaria	3		*	*	*	*	*	*	*	*	*	*	
Red Queen	3		*	*	*	*	*	*	*	*	*	*	*
Ribston	3		*	*	*	*	*	*	*	*	*	*	
Rolfe	4		*	*	*	*	*	*	*	*	*	*	
Vandevere Improved	3		*	*	*	*	*	*	*	*			
Wheeler No. 36	3		*	*	*	*	*	*	*	*			
Wheeler No. 44	3		*	*	*	*	*	*	*	*			
Winesap	3		*	*	*	*	*	*	*	*	*	*	
Yellow Forest	3		*	*	*	*	*	*	*	*	*		
Yellow Newton	5		*	*	*	*	*	*	*	*	*	*	
Zora	3		*	*	*	*	*	*	*	*	*		
Barringer	3			*	*	*	*	*	*	*	*	*	*
Black Ben Davis	3			*	*	*	*	*	*	*	*	*	
Bostick Queen	3			*	*	*	*	*	*	*	*	*	*
Coffelt	5			*	*	*	*	*	*	*	*	*	

TABLE VIII — *Continued.*

APPLES.

	No of obser-vations	May																			
		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Delicious	3									*	*	*	*	*	*	*	*	*	*	*	*
Fraker	6									*	*	*	*	*	*	*	*	*	*		
Johnsonite	3									*	*	*	*	*	*	*	*	*	*	*	
King of Pippins	3									*	*	*	*	*	*	*	*	*	*	*	
Longkeeper	3									*	*	*	*	*	*	*					
Luckey	3									*	*	*	*	*	*	*	*	*			
Missouri Pippin	3									*	*	*	*	*	*	*	*	*			
Oliver	3									*	*	*	*	*	*	*	*	*	*	*	*
Rome	6									*	*	*	*	*	*	*	*				
Sweet Longfield	3									*	*	*	*	*	*	*	*				
Wheeler No. 33	3									*	*	*	*	*	*	*	*	*			
Winter Citron	3									*	*	*	*	*	*						
Barry	4										*	*	*	*	*	*	*	*	*	*	*
Beach	3										*	*	*	*	*	*	*				
Bloomfield	3										*	*	*	*	*	*	*	*	*		
Caville de Oullins	4										*	*	*	*	*	*	*	*	*	*	
Cox Orange	3										*	*	*	*	*	*	*	*	*		
Czar Thorn	3										*	*	*	*	*	*	*	*	*		
Mock	3										*	*	*	*	*	*	*	*	*		
Ashton	3											*	*	*	*	*	*	*			
Prince Albert	3											*	*	*	*	*	*	*			
Ralls	3											*	*	*	*	*	*	*	*	*	*
Cagle Seeding	3												*	*	*	*	*	*	*	*	*

TABLE VIII — *Continued.*

GRAPES.

	No. of observations	June																								July				
		7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	5	4
Vitis solonis	7	*	*	*	*	*	*	*	*	*	*																			
Berckmans	4		*	*	*	*	*	*	*	*	*																			
Clevener	7		*	*	*	*	*	*	*	*	*																			
Clinton	[illegible]		*	*	*	*	*	*	*	*	*	*																		
Janesville	7		*	*	*	*	*	*	*																					
Marion	7		*	*	*	*	*	*	*	*	*	*																		
Vitis mexicana	7			*	*	*	*	*	*	*	*	*	*	*	*	*														
Brown	4				*	*	*	*	*	*	*	*	*	*	*															
Champion	4				*	*	*	*	*	*	*	*	*																	
Lutie	4				*	*	*	*	*	*	*	*	*																	
Mary Favorite	7				*	*	*	*	*	*	*	*	*																	
Vitis champini	6				*	*	*	*	*	*	*																			
Faith	7					*	*	*	*	*	*	*	*	*																
Vitis cupestris	7					*	*	*	*	*	*	*	*	*																
Arkansaw	4						*	*	*	*	*	*	*	*	*															
Chautauqua	4						*	*	*	*	*	*	*	*																
Colerain	4						*	*	*	*	*	*	*	*	*	*	*													
Early Victor	4						*	*	*	*	*	*	*	*	*	*	*	*												
Elvira	7						*	*	*	*	*	*	*	*	*	*														
Esther	4						*	*	*	*	*	*	*	*	*	*	*													
Grein Golden	4						*	*	*	*	*	*	*	*	*	*	*													
Pearl	7						*	*	*	*	*	*	*	*	*	*	*													
Rockwood	4						*	*	*	*	*	*	*	*	*	*	*	*	*											
Ulster	7						*	*	*	*	*	*	*	*	*	*														
Vitis doaniana	7						*	*	*	*	*	*	*	*	*															
Vitis labrusca	6						*	*	*	*	*	*	*	*	*	*	*	*												
White Jewel	7						*	*	*	*	*	*	*	*	*	*	*													
Wyoming	4						*	*	*	*	*	*	*	*	*	*	*													
Alexander Winter	4							*	*	*	*	*	*	*	*															
Beagle	7							*	*	*	*	*	*	*	*	*	*													
Bertha	4							*	*	*	*	*	*	*	*	*	*	*	*											
Canada	7							*	*	*	*	*	*	*	*	*	*													
Caywood No. 50	7							*	*	*	*	*	*	*	*															
Chandler	4							*	*	*	*	*	*	*	*	*	*	*												
Cottage	7							*	*	*	*	*	*	*	*															
Etta	7							*	*	*	*	*	*	*	*	*	*	*												

TABLE VIII — *Continued.*

GRAPES.

	No. of observations	June																								July				
		7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5
Illinois City	4							*	*	*	*	*	*	*	*	*	*	*	*	*	*									
Marvin Seedling	4							*	*	*	*	*	*	*	*	*	*	*	*											
Noah	7							*	*	*	*	*	*	*	*	*	*	*												
Thompson No. 5	4							*	*	*	*	*	*	*	*	*	*													
Victoria	4							*	*	*	*	*	*	*	*	*	*	*	*											
Vitis vulpina	6							*	*	*	*	*	*	*	*	*	*	*												
Wheaton	4							*	*	*	*	*	*	*	*	*	*	*	*	*	*									
Amber Queen	6								*	*	*	*	*	*	*	*	*	*	*	*	*									
Jessica	6								*	*	*	*	*	*	*	*	*	*	*											
Salem	6								*	*	*	*	*	*	*	*	*	*	*											
Wilder	6								*	*	*	*	*	*	*	*	*	*												
Worden	6								*	*	*	*	*	*	*	*	*	*	*	*	*	*	*							
Amber	7								*	*	*	*	*	*	*	*														
Ambrosia	7								*	*	*	*	*	*	*	*														
Antoinette	8								*	*	*	*	*	*	*	*	*	*	*	*										
Early Market	7								*	*	*	*	*	*	*	*	*	*	*											
Early Ohio	6								*	*	*	*	*	*	*	*	*	*	*											
Edmeston No. 1	4								*	*	*	*	*	*	*	*	*	*	*	*	*									
Elvibach	7								*	*	*	*	*	*	*	*	*	*												
Hartford	7								*	*	*	*	*	*	*	*	*	*												
Herald	7								*	*	*	*	*	*	*	*	*	*	*	*	*	*								
Herbert	7								*	*	*	*	*	*	*	*	*	*												
Little Blue	7								*	*	*	*	*	*	*	*	*													
Merrimac	7								*	*	*	*	*	*	*	*	*	*	*											
Missouri Reisling	7								*	*	*	*	*	*	*	*	*	*	*											
Montefiore	7								*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	**				
Northern Muscadine	7								*	*	*	*	*	*	*	*	*	*	*											
Perkins	7								*	*	*	*	*	*	*	*	*	*												
Profitable	7								*	*	*	*	*	*	*	*	*	*												
Witt	4								*	*	*	*	*	*	*	*	*	*	*	*	*									
Barry	6									*	*	*	*	*	*	*	*	*	*	*										
Concord	6									*	*	*	*	*	*	*	*	*	*	*	*	*								
Moore Early	6									*	*	*	*	*	*	*	*	*	*											
Pocklington	6									*	*	*	*	*	*	*	*	*	*	*	*									
Rochester	6									*	*	*	*	*	*	*	*	*	*											
Woodruff	5									*	*	*	*	*	*	*	*	*	*	*	*									

Amina	7	*	*	*	*	*	*	*	*									
Diana	7	*	*	*	*	*	*	*	*	*								
Dracut Amber	7	*	*	*	*	*	*	*	*									
Essex	7	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	**
Glenfield	7	*	*	*	*	*	*	*	*	*								
Hercules	7	*	*	*	*	*	*	*	*									
Isabella Seedling	7	*	*	*	*	*	*	*	*									
Leavenworth	6	*	*	*	*	*	*	*	*	*								
Mabel	7	*	*	*	*	*	*	*	*	*	*	*						
Marie Louise	4	*	*	*	*	*	*	*	*	*	*	*	*	*				
Requa	5	*	*	*	*	*	*	*	*	*	*	*	*					
Rogers No. 13	7	*	*	*	*	*	*	*	*	*								
Rogers No. 24	7	*	*	*	*	*	*	*	*	*	*	*	*					
Rogers No. 32	7	*	*	*	*	*	*	*	*	*	*	*	*					
Standart	7	*	*	*	*	*	*	*	*	*								
Telegraph	7	*	*	*	*	*	*	*	*	*								
Thompson No. 7	3	*	*	*	*	*	*	*	*	*	*							
Vitis arizonica	6	*	*	*	*	*	*	*	*	*	*	*						
Brighton	6		*	*	*	*	*	*	*	*	*	*	*					
Burnet	6		*	*	*	*	*	*	*	*	*	*	*					
Catawba	6		*	*	*	*	*	*	*	*	*	*	*					
Hayes	6		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Monroe	6		*	*	*	*	*	*	*	*	*	*						
Vergennes	6		*	*	*	*	*	*	*	*	*	*	*					
Aledo	6		*	*	*	*	*	*	*	*	*	*	*					
Delaware	6		*	*	*	*	*	*	*	*	*	*	*					
Gold Dust	7		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Golden Grain	7		*	*	*	*	*	*	*	*	*	*						
Jewell	6		*	*	*	*	*	*	*	*	*	*	*	*				
Juno	7		*	*	*	*	*	*	*	*	*	*	*					
Leader	3		*	*	*	*	*	*	*	*	*	*	*					
Lindmar	6		*	*	*	*	*	*	*	*	*							
Maxatawney	6		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Nectar	7		*	*	*	*	*	*	*	*	*	*	*	*	*	*		
Paradox	7		*	*	*	*	*	*	*	*	*	*	*	*	*			
Paragon	7		*	*	*	*	*	*	*	*	*	*	*					
Red Bird	7		*	*	*	*	*	*	*									
Red Eagle	7		*	*	*	*	*	*	*	*	*	*	*					
Roenbeck	3		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Roscoe	6		*	*	*	*	*	*	*	*	*	*	*	*	*	*		
Shull No. 2	3		*	*	*	*	*	*	*	*	*	*	*					
Winchell	7		*	*	*	*	*	*	*	*	*	*	*	*				
Centennial	6			*	*	*	*	*	*	*	*	*	*	*				
Dutchess	6			*	*	*	*	*	*	*	*	*						
Eumelan	5			*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Isabella	5			*	*	*	*	*	*	*	*	*	*	*				
Niagara	5			*	*	*	*	*	*	*	*	*	*	*				
Norwood	6			*	*	*	*	*	*	*	*							

TABLE VIII — *Concluded.*

GRAPES.

	No. of obser-vations.	June.																								July.				
		7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5
Alice	6											*	*	*	*	*	*	*	*	*	*	*	*	*						
America	4											*	*	*	*	*	*	*	*	*	*									
Croton	6											*	*	*	*	*	*	*	*	*	*	*								
Daisy	5											*	*	*	*	*	*	*	*											
Gaertner	7											*	*	*	*	*	*	*	*	*	*	*	*							
Hopican	7											*	*	*	*	*	*	*	*	*	*	*	*	*	*					
Livingston	3											*	*	*	*	*	*	*	*	*	*	*	*							
Mathilde	7											*	*	*	*	*	*	*	*	*	*	*	*	*	*					
Olita	7											*	*	*	*	*	*	*	*	*	*	*	*	*	*					
Rommel	6											*	*	*	*	*	*	*	*	*	*	*	*	*	*					
Rutland	7											*	*	*	*	*	*	*	*	*	*	*								
Lindley	5												*	*	*	*	*	*	*	*	*	*	*	*						
Eaton	5												*	*	*	*	*	*	*	*	*	*	*							
Lady Washington	5												*	*	*	*	*	*	*	*	*	*								
Adirondack	6												*	*	*	*	*	*	*	*										
Canonicus	7												*	*	*	*	*	*	*	*	*									
Creveling	6												*	*	*	*	*	*	*	*	*	*								
Dr. Hexamer	4												*	*	*	*	*	*	*	*	*	*	*							
Massasoit	6												*	*	*	*	*	*	*	*	*	*	*	*	*					
Metternich	7												*	*	*	*	*	*	*	*	*	*	*							
Rogers No. 5	6												*	*	*	*	*	*	*	*	*	*								
Gold Dust	5												*	*	*	*	*	*	*	*										
Golden Grain	5													*	*	*	*	*	*	*										
Agawam	5													*	*	*	*	*	*	*	*									
Jefferson	6													*	*	*	*	*	*	*	*	*	*	*						
Senasqua	6													*	*	*	*	*	*	*										
Big Hope	4													*	*	*	*	*	*	*	*	*	*	*						
Brighton	6													*	*	*	*	*	*	*	*	*								
Brilliant	6													*	*	*	*	*	*	*	*	*	*							
Collier (Dr.)	4													*	*	*	*	*	*	*	*	*	*							
Geneva	6													*	*	*	*	*	*	*	*									
Ross	4													*	*	*	*	*	*	*	*	*	*	*						
Rustler	6													*	*	*	*	*	*	*	*	*	*							
Blanco	4													*	*	*	*	*	*											
Denison	3													*	*	*	*	*	*	*										
Lindmar	5													*	*	*	*	*	*	*										

Opal	5	*	*	*	*	*	*	*								
Empire State	5		*	*	*	*	*	*	*							
Iona	5		*	*	*	*	*	*	*	*						
Black Eagle	6		*	*	*	*	*	*	*	*	*	*	*			
Diamond	6		*	*	*	*	*	*	*	*	*	*	*			
Early Golden	3		*	*	*	*	*	*	*	*	*	*	*			
Eldorado	6		*	*	*	*	*	*	*	*						
Fern Munson	4		*	*	*	*	*	*	*	*	*					
Big Extra	4			*	*	*	*	*	*	*	*	*	*			
Carman	4			*	*	*	*	*	*	*	*	*	*			
Mills	4			*	*	*	*	*	*	*	*	*	*	*		
Triumph	4			*	*	*	*	*	*	*	*	*	*	*	*	*
Big B. Con	4				*	*	*	*	*	*	*	*	*	*	*	
Vitis aestivalis	5				*	*	*	*	*	*	*	*				
Bailey	3					*	*	*	*	*	*	*	*	*		
Elsinburgh	5					*	*	*	*	*	*	*	*	*	*	

VARIETY TEST OF STRAWBERRIES AND CULTURAL DIRECTIONS.*

O. M. TAYLOR.

SUMMARY.

Eighty-nine varieties, tested during 1907 and 1908, many of them recent introductions, are described in this bulletin. The kinds have varied widely in behavior under apparently similar conditions, and these differences indicate their possible value when grown in a similar environment. Actual trial under each set of conditions is the safest guide.

The distance of rows and plants should be governed by the plant's ability to reproduce itself. This is an inherent character which varies but little under different surroundings. Eleven varieties produced very many plants which were badly crowded. Thirty-two kinds made very few plants leaving much unoccupied ground which resulted in a decreased yield. Forty-six varieties developed a medium number of runners.

No insect injury occurred during 1907 and 1908. Weather conditions were unfavorable for the rapid outbreak and spread of fungus diseases. A few varieties suffered from mildew. Twenty varieties were strongly susceptible to attacks of leaf-blight. Sixty nine kinds were free from disease, or nearly so. Under ordinary conditions applications of bordeaux mixture are unnecessary.

A large number of varieties fruited in midseason. Nineteen per ct. proved to be early; about eight per ct. were late. Small size and a short and unproductive season are characteristics of early varieties. Golden Gate and Saint Louis were very productive and early in season. Most of the early kinds produced only one or two satisfactory pickings. There were a larger number of desirable midseason and late kinds than early varieties. All of the seven late varieties, Blaine, Columbia, Nettie, Prof. Fisher, Quality, Rough Rider and Williams are included in the list of varieties having marked desirable characters.

One of the greatest variations was in productiveness. The rating of each is given in the description of the variety. The most

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productive kind, Arnouts, yielded at the rate of 14,409 quarts per acre; the least productive variety, Stevens Late Champion, yielded at the rate of 622 quarts per acre. This variety, however, produced very few runners. It has many qualities to commend it and is worthy of trial notwithstanding the record of yield. Nineteen varieties gave a yield of from 8,189 to 14,409 quarts per acre, and only nine varieties gave a yield of from 2,807 quarts down to 622 quarts per acre.

For commercial purposes large size of fruit is essential. Many kinds otherwise desirable produce berries too small. Some desirable kinds such as Carrie Silvers, Dighton Rock, Ernie, Senator Dunlap, Williams, and others produced large fruit which rapidly decreased in size as the season advanced. On page 481 is given a list of thirty-eight varieties which retained their size fairly well throughout the season.

Early blooming varieties often suffer from frost. Those which open their buds late are usually safer to grow. The blooming season may be retarded slightly as indicated under cultural directions. Fourteen varieties blossomed early and a similar number bloomed late. Abington, an early bloomer, ranked high in productiveness and in color, although not of highest quality. All but three of the fourteen late bloomers are in the group of desirable kinds.

The list of varieties with marked desirable characters is large. Many varieties are included which made a good record in the previous test and these have nearly all held their own during the past two years. The list is only suggestive. It is not expected that all will do equally well in any one place. The important characteristics are noted in the descriptions. Attention is here called to a few of the most promising sorts. Amanda, although subject to leaf blight, is a heavy yielder of large, well colored berries of high quality. Blaine is an excellent shipper and ranks very good in quality. Cardinal, Mark Hanna, Marshall, Mead, President, Rough Rider and Senator Dunlap are well known in many sections. Chesapeake, a most promising kind, produced few plants, which were healthy and vigorous. The plump, glossy scarlet surface, smooth except for the raised seeds, is characteristic. Columbia has excellent plant habits; the large glossy, light scarlet berries have good flesh characters; one of the best late ripening kinds. Dighton Rock lacks somewhat in vigor but ranks very good to best in quality. Golden Gate produced vigorous and very productive plants, ripening its fruit medium early; an excellent shipper. Good Luck is

worthy of more extended trial; the flesh is sprightly acid and pleasant flavored. Magnus, a Station seedling, ranked first in attractiveness. Millionaire was not sufficiently tested to determine its value. The dark green healthy foliage of Nettie, a late variety, attracted attention, as did the large and slightly dull scarlet fruit; resembles Prof. Fisher but earlier. President again demonstrated its value as a show berry. Prof. Fisher made a good record as a productive, late, tart variety, but is coarse in appearance. Prolific, a Station seedling, ranked at the front and appears unusually well adapted for commercial purposes. Although the plant characters of Saratoga are not perfect, the fruit is large, well shaped, attractive, dark scarlet; an excellent shipper; sprightly acid and of a good to very good quality. Stevens Late Champion ranked low in yield and was inclined to green tips but the plant characters were good and the fruit was usually attractive; should be set closer than most varieties. "Three W" gave the highest yield in 1908 (12,342 quarts per acre) and may have value on account of productiveness although the shape is variable; flesh is unusually dark red.

The cultural notes are brief suggestions along desirable lines. The details must vary to suit each set of conditions; the general principles of plant and soil requirements remain unchanged.

INTRODUCTION.

Two seasons have passed since the last publication of this Station on strawberries was issued. During this time eighty-nine varieties have been tested, and it is the purpose of the present bulletin to report the results obtained. Most of the varieties are recent introductions but some standard kinds are included for purposes of comparison. Whenever possible, plants were obtained from the originator or introducer and great care was given at all times to secure stock true to name.

The success of any variety depends largely upon two things, its adaptation to environment and the amount of moisture available just before and during the fruiting period. Certain factors cannot be modified to any extent, but the amount of plant food available and the conservation of moisture are largely dependent upon the efforts of each grower, and vary with the care given. Seasons are unlike. Conditions widely different may exist at the same time in closely related territory. For these reasons the details of weather conditions for 1907 and 1908 are omitted. Average crops of berries

were produced generally although the yield was decreased in some localities by lack of rainfall or by other causes.

The results given in this bulletin must not be taken as an index to the value of a variety in all locations and under all conditions. They indicate only the character of plant and fruit development under the local conditions existing at this Station, pointing out the strong and weak tendencies as they have appeared. It must be said again that the true value of a variety for each location can be determined only by actual trial in that place.

Brief cultural suggestions were given in the previous bulletin. The demand for copies has been so great that the supply is exhausted. For this reason the description of varieties is followed by a revision of the brief cultural notes which may in a measure answer the numerous inquiries coming to this Station in regard to growing strawberries.

NOTES ON VARIETIES.

Plant makers.— Varieties differ widely in their ability to make new plants, and this tendency should be considered in determining the distance of planting. To make conditions uniform, however, in this experiment all plants, except where noted, were set three feet by two feet. This distance was too great in some cases, resulting in a decreased yield. Other varieties made an unusually large number of plants which should have been thinned out or given more room. The following are lists of varieties producing very many or very few plants:

VERY MANY PLANTS.

Abington	Columbia	Prolific
Advance	*Edwards No. 1*	Ridgeway
Amanda	Mark Hanna	Senator Dunlap
Cardinal	Pineapple Flavored	

VERY FEW PLANTS.

Chesapeake	Klondike	Pres. Roosevelt
Dighton Rock	Latest	Prof. Fisher
Elma	Mead	Star
Florella	Miss Boston	Stevens Late Champion
Gem	Morning Star	Three W
Gill	Nehring's Gem	Uncle Sam
Gladstone	New Home	Velvet
Great Scott	Nimrod	Victor
Helen Gould	North Shore	Virginia
Hundred Dollar	Olympia	Williams
Joe	Oswego	

Resistance to disease.— The amounts of leaf blight and mildew were noted from time to time during the growing season. The extent of these injuries is often largely determined by soil and air drainage and by the frequency and duration of rainfall, and varies widely in different years. Under similar conditions, however, there was considerable variation in the ability of different varieties to withstand attacks of fungi. These differences are recorded in the description of varieties. Fifty-five varieties were wholly free from disease, fourteen varieties but slightly affected, and twenty varieties considerably injured, principally by leaf blight.

Season of ripening.— In some localities the commercial value of a variety is largely determined by the time at which the fruit is ready to harvest. Some markets require early fruit while others find the late varieties most satisfactory. The terms early, midseason and late, as used in this bulletin, are relative, referring to comparative time of ripening rather than to specific dates. The following table shows that seventeen varieties ripened early and only seven late, while a large majority, sixty-five in number, fruited in midseason.

EARLY SEASON.

Advance	Ernie	Miss Boston
Almo	Excelsior	Oaks Early
Chipman	Fairfield	Pres. Roosevelt
Colossus	Florella	*Riehl No.* 28
Early Beauty	Gill	Saint Louis
Ekey	Golden Gate	

LATE SEASON.

Blaine	Prof. Fisher	Rough Rider
Columbia	Quality	Williams
Nettie		

Productiveness.— During the ripening period the fruit was picked and weighed several times each week as occasion required. As the rows of the different varieties were not of the same length the total weight was reduced to the estimated yield per acre for comparison. No less than 12 plants of a variety were set, and in some cases the rows included 100 or more plants. The results indicate wide ranges in productiveness, varying from 14,409 quarts per acre in the case of Arnouts to 622 quarts per acre with Stevens Late Champion. The latter variety, however, produced very few runners and the original plants might have been set much closer, which would have

materially increased the yield per acre. The following is a list of varieties producing heavy and light yields:

VERY PRODUCTIVE.

Abington	King Edward	Prolific
Amanda	Mead	Saint Louis
Arnouts	New Globe	Saratoga
Bradley	Oneida	Senator Dunlap
Columbia	Oswego	Three W
Golden Gate	President	World's Wonder
Hundred Dollar		

UNPRODUCTIVE.

Elma	Morning Star	Olympia
Gill	Nimrod	Stevens Late Champion

Size of fruit.— At the first picking of each variety, the size of the berries was noted and this record compared with the size of the fruit at each succeeding picking. Many of the varieties of good quality and attractive color were deficient in size throughout the season. Others produced fruit of excellent size at first, which later decreased greatly. Still others retained a satisfactory size to the close of the season, a most desirable character for a good commercial variety. The fact must not be overlooked, however, that size is not the only factor to be considered, for some varieties were unattractive in color or undesirable in shape although of excellent size. The following list of thirty-eight varieties retained their size fairly well throughout the season.

DESIRABLE SIZE THROUGHOUT SEASON.

Abington	Good Luck	Prof. Fisher
Amanda	Gov. Rollins	Prolific
Arnouts	Great Scott	Ridgeway
Blaine	Hundred Dollar	Rough Rider
Bountiful	Joe	Saratoga
Cardinal	Klondike	*Schauber No.* 106
Chesapeake	Latest	*Schauber No.* 108
Columbia	Magnus	Star
Colossus	Mark Hanna	Stevens Late Champion
Ekey	Marshall	Uncle Jim
Elma	Mead	Uncle Sam
Gladstone	Nettie	Velvet
Golden Gate	President	

Blooming season.— In some parts of the State and in localities subject to late frosts the time of blooming is of great importance as a large proportion of the blossoms are often killed by low temperatures at blooming time. The date of bloom varies, depending considerably upon the season and on the amount of winter protection given in order to keep the plants back as much as possible. Records were kept of the date of the opening of the first blossoms and from these data the kinds have been grouped according to the relative time of blossoming into early, midseason and late bloomers. Fourteen varieties bloomed early and fourteen were late in coming into bloom. The following is the list:

EARLY BLOOMERS.

Abington	Fairfield	Nimrod
Advance	Florella	Oak's Early
Chipman	Gill	Olympia
Early Beauty	Morning Star	Somerset Maid
Excelsior	Mrs. Miller	

LATE BLOOMERS.

Amanda	Good Luck	Quality
Blaine	Joe	*Schauber No.* 106
Chesapeake	Magnus	*Schauber No.* 108
Columbia	Millionaire	Williams
Elma	Prof. Fisher	

Desirable kinds.— Of all fruits the strawberry is one of the most variable in its behavior in different localities and under changed conditions. A variety may succeed in one place and fail in another place even in closely related territory. It is therefore unsafe to plant largely of any kind, no matter how well recommended, without a preliminary trial to test its adaptability to the proposed location. Nor is it generally desirable to include too many varieties in the main plantation for commercial purposes. A conservative study should therefore be made of the large list given below. These include the varieties which have strongly shown desirable characters along important lines. These characters are fully noted in the description of the variety. None of these kinds is perfect in all points and doubtless some will be discarded after a longer test. The fifty-four varieties not included in the list did not succeed well in the test at this Station. Those marked with a star should be planted closer than the other varieties.

VARIETIES HAVING MARKED DESIRABLE CHARACTERS.

Abington	Golden Gate	*Prof. Fisher
Amanda	Good Luck	Prolific
Blaine	Gov. Rollins	Quality
Bountiful	*Joe	Rough Rider
Cardinal	Magnus	Saratoga
Carrie Silvers	*Mark Hanna	*Schauber No.* 106
*Chesapeake	Marshall	Senator Dunlap
Columbia	*Mead	*Stevens Late Champion
*Dighton Rock	*Nehring's Gem	*Three W
*Elma	Nettie	*Uncle Sam
Ernie	Omega	*Williams
*Gladstone	President	

DESCRIPTION OF VARIETIES.

In the following descriptions the source of the plants tested is indicated by the names in parentheses following the names of varieties. Most of the historical information was secured directly from the originators or introducers.

Abington.— (W. F. Allen, Salisbury, Md.) Perfect. A chance seedling originated in 1895 by Lester Blanchard, Abington, Massachusetts, and introduced by him in 1905. Plants many in number, strongly vigorous, subject to attacks of leaf blight, very productive. Leaves large, dark green; leaf stems long, variable in thickness. Fruit stems long, thick, usually double, medium erect. Blooms medium early, ripens slightly before midseason, picks easily. Calyx of medium size, flat or often on a short neck, sometimes slightly discolored. Seeds somewhat sunken. Fruit large, wedge to roundish conic or sometimes slightly elongated, attractive light scarlet. Flesh rather light colored, moderately firm, mildly acid, fair to good in quality. Retains size well throughout the season. Not of highest quality or firmness but worthy of trial on account of productiveness and general attractiveness.

Advance.— (W. F. Allen, Salisbury, Md.) Perfect. Introduced about 1904 by Arthur B. Printz of Indiana. Plants very numerous, vigorous, healthy, above medium in productiveness. Leaves medium to above in size, light green; leaf stems rather long, slender. Fruit stems long, medium to slender, single, prostrate. Blooms and ripens early, picks easily. Calyx small to medium, not leafy, dis-

***Make few runners. Should be set closer.**

colored, flat, often pale green. Seeds slightly sunken. Fruit averages medium in size, strongly elongated, apex sharp pointed, attractive medium to light scarlet. Flesh medium red, rather soft, considerably acid, not high in flavor, poor to fair in quality. Not desirable in size or shape.

Almo.— (J. A. Bauer, Judsonia, Ark.) Imperfect. Originated in 1902 and introduced in 1905 by J. A. Bauer, Judsonia, Arkansas. Grown from seed obtained by crossing Clyde and Crescent. Plants medium in number, vigorous, healthy, productive. Leaves large, dark green; leaf stems long, thickish. Fruit stems of fair length, thick, double, semi-erect. Blooms in midseason, ripens early, picks easily. Calyx small to medium, discolored, slightly sunken to flat. Seeds depressed to medium. Fruits large, drops rapidly in size as the season advances, attractive roundish conic, dark glossy scarlet. Flesh well colored, very firm, agreeably acid, not high in flavor, quality fair. A dark red berry of desirable shape.

Amanda. — (J. Whitt, Vermilion, O.) Perfect. Originated by Z. T. Mumma, Bluffton, Ohio, in 1904. The stock is now controlled by Mr. Whitt. Not yet introduced to the trade. A seedling of Sample crossed with Maximus. Plants very numerous, vigorous, subject to attacks of leaf blight, a heavy yielder. Leaves of average size and color; leaf stems long, medium to slender. Fruit stems long, medium to very thick, branched, somewhat erect. Blooms late, ripens in midseason, picks easily. Calyx medium in size, somewhat discolored, sunken to flat. Seeds strongly depressed. Fruit of large size which holds well throughout the season, wedge to roundish conic, light and dark scarlet, slightly glossy. Flesh well colored, very firm, agreeably acid, pleasant flavor, quality good. Has many qualities which commend it for more extended trial.

Arkansas Black. —(M. Crawford Co., Cuyahoga Falls, O.) Perfect. Originated in 1900 by Louis Hubach, Judsonia, Arkansas, and introduced about 1904 by Hubach and Hathaway, of that place. Mr. Hubach states that it is a seedling of Lucretia Dewberry crossed with one of his seedling strawberries. Although twelve plants were set of this variety, nearly all failed to grow. The remainder appeared to be moderately vigorous, productive and healthy. Calyx medium to small, often discolored, usually slightly raised. Seeds depressed. Fruit large to medium, roundish conic, blunt, very dark scarlet. Flesh of good color, firm, mildly acid, agreeable

flavor, good to very good in quality. The few plants fruiting would indicate an early season. The color of fruit is the darkest of all the varieties described in this bulletin. Not enough plants for a satisfactory test.

Arnouts.—(W. F. Allen, Salisbury, Md.) Perfect to semi-perfect. Originated by J. R. Arnout of Pennsylvania. Plants medium in number and vigor, susceptible to attacks of leaf blight, very productive, yielding at the rate of 14,409 quarts per acre. Leaves of average size and color; leaf stems medium in length, rather slender. Fruit stems medium to long, inclined to thick, prostrate. Blooms and ripens in midseason, picks medium easily. Calyx medium to small, often discolored, slightly depressed. Seeds numerous, somewhat sunken, slightly hairy. Fruit large to medium, wedge to roundish conic, surface irregularly furrowed, rather dull dark scarlet. Flesh medium red, firm, mildly acid, quality good. Irregular in shape, inclined to green tips, seedy appearance, dull, unattractive, wrinkled surface. Chief value appears to be productiveness.

Blaine.— (J. W. Blaine, Polk City, Iowa.) Semi-perfect to perfect. Originated by Mr. Blaine in 1902, and first sent out in 1907. Thought to be a cross of Beder Wood and Lovett as the original plant was found in a patch of these varieties. Plants numerous, vigorous, subject to mildew, below medium in productiveness. Leaves of medium size and color, inclined to curl on account of mildew. Leaf stems long, medium to thick. Fruit stems long, inclined to thick, somewhat erect. Blooms and ripens late, picks easily. Calyx large, leafy, attractive green, flat to raised. Seeds raised, numerous. Fruit large to medium, retains size well throughout the season, blunt, roundish conic, medium to light attractive scarlet. Flesh medium red, very firm, pleasant acid, agreeable flavor, very good in quality. Some berries rather light in color. Worthy of further testing. Flesh characters desirable.

Bountiful.— (J. E. Kuhns, Cliffwood, N. J.) Perfect. First fruited in 1899 by Mr. Kuhns and introduced by him in the spring of 1908. Said to be a seedling of Glen Mary probably crossed with Clyde. Plants numerous, vigorous, susceptible to attacks of leaf blight, above medium in productiveness. Leaves rather large, medium dark green. Leaf stems above medium in length, inclined to slender. Fruit stems medium to short, variable in thickness. Blooms early in midseason, ripens slightly before midseason, picks

medium easily. Calyx medium to rather small, often discolored, sometimes slightly sunken. Seeds numerous, somewhat depressed. Fruit large to medium, retains size well in late pickings, roundish conic, medium dark scarlet. Flesh well colored, firm, mildly acid, pleasant flavor, quality good. In later pickings many berries hard and seedy at apex. The fruit is medium attractive ranking slightly above the average in general appearance and in flesh characters.

Bradley.— (Geo. R. Schauber, Ballston Lake, N. Y.) Perfect. Originated at Cobden, Illinois, by J. H. Bradley, about 1896. A seedling of Crescent open to chance pollination by Tennessee Prolific and Crystal City. Plants of medium number, somewhat vigorous, healthy, very productive. Leaves medium to large, dark green Leaf stems inclined to long, slender. Fruit stems long, not thick, often single, semi-erect. Blooms and ripens in midseason, picks easily. Calyx of average size, not leafy, rather pale green, sunken. Seeds variable in depth. Fruit large to medium, varies considerably in size, irregular roundish conic to slight wedge, dull light to medium dark scarlet. Flesh rather light colored, medium to firm, rather acid, not high in flavor, quality poor to fair. Not equal to the best standard varieties.

Cardinal.—(G. J. Streator, Garrettsville, O.) Imperfect. A self-sown seedling originated by Mr. Streator in 1896. Nothing is certain concerning its parentage but it is thought to be of Warfield descent. The stock was sold to the Templin Company, Calla, Ohio, who introduced the variety in the spring of 1905. Plants very numerous, vigorous, healthy, productive. Leaves medium to large, dark green; leaf stems above medium to long, rather thick. Fruit stems variable in length, stout, often double, semi-erect. Blooms and ripens about midseason, picks easily. Calyx medium to large, leafy, usually not depressed, often discolored. Seeds raised, numerous. Fruit above medium to large, retains its size fairly well till close of season, roundish conic, sometimes inclined to wedge, slightly necked, rather dark, dull or sometimes glossy scarlet. Flesh good color, firm, juicy, rather acid, agreeable flavor, quality good. Has many qualities which commend it.

Carrie Silvers.—(J. H. Black, Son & Co., Hightstown, N. J.) Imperfect. Originated in 1893 by Black, Son & Co., and introduced by them in 1899. A seedling of Sharpless and Warfield

crossed by Parker Earle. Plants medium to numerous, vigorous, healthy, productive. Leaves above medium to very large, dark green; leaf stems long, medium to thick. Fruit stems inclined to short, single, prostrate. Blooms and ripens in midseason, picks medium easily. Calyx of fair size, slightly reflexed, medium green, somewhat raised. Seeds raised slightly. Fruit large, drops rapidly in size as the season advances, slightly elongated to roundish conic, blunt at apex, inclined to a neck at base, attractive, glossy, medium dark scarlet. Flesh dark red, firm, pleasant acid, agreeable flavor, good to very good. Excellent showing. Has many qualities to commend it for trial.

Chesapeake.— (W. F. Allen, Salisbury, Md.) Perfect. Takes its name from Chesapeake Bay. Plants few, rather vigorous, healthy, productive. Leaves above medium in size, rather dark green; leaf stems medium to above in length, inclined to thick. Fruit stems medium to above in length, thick, usually branched, semi-erect. Blooms late, ripens in midseason, picks easily. Calyx large, leafy, attractive green, slightly depressed. Seeds markedly raised, numerous. Fruit large, roundish conic to wedge, surface plump, unbroken by furrows, attractive glossy scarlet. Flesh fairly good color but sometimes rather light, very firm, mildly acid, pleasant flavor, quality good to very good. Plants should be set closer than most varieties. The plump, glossy surface, smooth except for the raised seeds, is characteristic of this variety. Worthy of extended trial.

Chipman.— (W. S. Todd, Greenwood, Del.) Perfect. Found by a Mr. Chipman, at Lincoln, Delaware, about 1901, growing in a plantation of Bubach and Tennessee Prolific. Introduced in 1907 by Mr. Todd. Plants very numerous, medium to vigorous, healthy, productive. Leaves of fair size, dark green; leaf stems medium to long, rather slender. Fruit stems inclined to long, thick, often branched, prostrate. Blooms and ripens early, picks easily. Calyx medium to large, sometimes leafy, light green, flat. Seeds sunken. Fruit large to medium, wedge to roundish conic, sometimes slightly elongated, surface somewhat irregular, rather attractive light and dark scarlet, becoming duller as the season advances. Flesh slightly light color, medium in firmness and juiciness, mild acid, pleasant but not high flavor, fair to good. Lacks somewhat in juiciness and in flavor. Size variable.

Columbia.— (J. B. Wild & Bros., Sarcoxie, Mo.) Imperfect. Plants very numerous, strongly vigorous, healthy, very productive. Leaves unusually large, dark green; leaf stems long, very thick. Fruit. stems long, thickish, often single, rather erect. Blooms and ripens late, picks easily. Calyx above medium to large, often leafy, usually slightly sunken. Seeds numerous, raised. Fruit large, often very large, wedge to roundish conic, attractive, glossy, light scarlet. Flesh well colored, firm, agreeably acid, pleasant flavor, good to very good in quality. Retains size well as the season advances. Desirable in size, color and shape. Flesh characters good. One of the most promising kinds.

Colossus.— (Geo. R. Schauber, Ballston Lake, N. Y.) Imperfect. Plants medium in number and vigor, healthy, productive. Leaves small to medium, dark green; leaf stems short to medium, slender. Fruit stems inclined to short, medium to slender, often single, prostrate. Blooms in midseason, ripens early, does not pick easily. Calyx medium to below in size, slightly leafy, attractive green, reflexed, flat to slightly sunken. Seeds variable in depth. Fruit large to medium, retains size well in later pickings, wedge to roundish conic, rather blunt, attractive, medium dark scarlet. Flesh medium red to light colored, firm, mildly acid, not high flavor, of fair quality. Attractive shape. Characters desirable except in flavor and quality.

Commander.— (Flansburgh & Potter, Leslie, Mich.) Perfect. This variety is of French stock imported and sold first in this country by J. H. Goldsburg, of Washington, D. C. Plants numerous, vigorous, susceptible to attacks of leaf blight, productive. Leaves medium to large, dark green; leaf stems of average length, rather slender. Fruit stems medium to above in length, of average thickness, rather prostrate. Blooms and ripens in midseason, picks medium easily. Calyx medium to above in size, often discolored, usually slightly raised. Seeds depressed. Fruit very large to medium, varies in shape from irregular wedge to roundish conic or slightly elongated, surface irregularly furrowed, light to dark scarlet, does not color uniformly. Flesh medium well colored, very mild, not juicy, inferior in flavor and quality. Coarse in general appearance. Fruit runs small in later pickings.

Dighton Rock.— (J. H. Hale, South Glastonbury, Conn.) Perfect. Plants few in number, below medium in vigor, healthy, pro-

ductive. Leaves small to medium, of average color. Leaf stems rather short, moderately thick. Fruit stems short to medium, often very thick, double, prostrate. Blooms and ripens in midseason, picks medium easily. Calyx medium to large, leafy, flat to slightly raised. Seeds sunken. Fruit large to medium, dropping rapidly in size as the season advances, attractive roundish conic, very blunt, medium to dark glossy scarlet. Flesh dark red, firm, agreeably acid, highly flavored, very good to best in quality. Unusually promising in flesh characters. Fruit runs small in late pickings. Worthy of trial.

Early Beauty. — (Woodlawn Nurseries, Rochester, N. Y.) Perfect. Originated in Iowa. Plants numerous, vigorous, healthy, productive. Leaves medium to small, medium green; leaf stems long, slender. Fruit stems long, not thick, branched. Blooms and ripens early. Picks easily. Calyx large to medium, leafy, attractive green, slightly sunken to flat. Seeds slightly depressed. Fruit above medium to small, roundish conic to slightly elongated, apex variable, often sharp pointed, surface of largest berries irregular, light to medium red. Flesh whitish, medium to firm, mildly sweet, not high in flavor, quality fair. Too small, and unattractive in color.

Echo. — (Woodlawn Nurseries, Rochester, N. Y.) Perfect. Introduced by the Woodlawn Nurseries. Plants of medium number, vigorous, slightly attacked by leaf blight, above medium in productiveness. Leaves medium to below in size, moderately light green; leaf stems of fair length, rather slender. Fruit stems medium to long, thick, usually double, somewhat erect. Blooms and ripens in midseason. Calyx medium to rather large, often leafy, slightly sunken. Seeds depressed. Fruit large to medium, drops in size as the season advances, roundish conic, apex very blunt, dull scarlet. Flesh whitish, juicy, rather firm, pleasant flavor, good to very good in quality. The fruit picks easily but lacks in size and is unattractive in color.

Edwards No. 1.—(M. B. Edwards, Franklin, N. Y.) Imperfect. A wildling found growing in a meadow in 1896 by Mr. Edwards. Parentage unknown. Plants very numerous, vigorous, healthy, productive. Leaves small to medium, rather dark green; leaf stems long, inclined to slender. Fruit stems often very long, slender, single, semi-erect. Blooms in midseason, ripens slightly after midseason, picks medium easily. Calyx medium to large, slightly leafy,

often pale green, flat. Seeds raised, numerous, giving a "seedy" appearance. Fruit medium to large, drops to small as the season advances, blunt wedge to roundish conic, rather attractive, medium dark scarlet. Flesh medium red, firm, rather acid, not high flavor, fair to good. With the exception of size and flavor, characters are desirable for a tart variety.

Ekey.—(M. Crawford Co., Cuyahoga Falls, Ohio.) Perfect. Originated in 1898 by E. H. Ekey, Steubenville, Ohio, and introduced by him in 1906. A seedling of Warfield fertilized by Belmont. Plants of medium number and vigor, susceptible to attacks of leaf blight and mildew, productive. Leaves of medium size and color; leaf stems short to medium, inclined to slender. Fruit stems short, thick, branched, prostrate to semi-erect. Blooms in midseason, ripens early, picks easily. Calyx large, leafy, discolored, flat to raised. Seeds raised to medium. Fruit large to medium, retains size well throughout the season, conical, strongly elongated, sharp pointed, dull, unattractive dark scarlet. Flesh dark red, medium to firm, considerably acid, unpleasant flavored, poor in quality. Many green tips. Undesirable.

Elma.—(M. Crawford Co., Cuyahoga Falls, Ohio.) Imperfect. Originated in 1900 by J. H. Black, Son & Co., Hightstown, New Jersey, and introduced by them in 1904. Robbie and Nettie were crossed producing a seedling which was crossed with Joe, thus giving Elma. Plants very few, medium in vigor, healthy, not productive. Leaves medium in size and color; leaf stems of fair length, inclined to slender. Fruit stems short to medium, variable in thickness, single, prostrate. Blooms late, ripens after midseason, picks medium easily. Calyx of fair size, not leafy, pale green, flat. Seeds raised. Fruit large to medium, retains size well as the season advances, blunt, roundish to slight wedge, light to medium scarlet. Flesh light color, firm, pleasant acid, agreeable flavor, quality good. Surface berries often not evenly colored. Should be planted closer than most varieties.

Ernie.—(A. R. Weston & Co., Bridgman, Mich.) Perfect. Originated by Dr. S. M. Mandlin, Bridgman, Michigan, in 1895. Introduced by Weston & Company in 1903. Parentage unknown. Plants medium in number, medium to vigorous, healthy, productive. Leaves above medium to large, dark green; leaf stems medium to long, slender to medium. Fruit stems variable in length, thickish,

double, prostrate. Blooms in midseason, ripens medium early, picks easily. Calyx medium to large, leafy, attractive green, variable in position, detaches easily. Seeds numerous, raised. Fruit above medium to large, drops in size as the season advances, roundish conic to slightly elongated or irregular wedge, surface of large berries furrowed, attactive, glossy, dark scarlet. Flesh of good color, firm, agreeably acid, high flavor, good to very good. General appearance slightly seedy. Has a number of desirable characters.

Excelsior.—(W. F. Allen, Salisbury, Md.) Perfect. Originated in 1890, by Louis Hubach, Judsonia, Arkansas, and introduced by J. C. Bauer of that place in 1892. A seedling of Hoffman crossed with Wilson. Plants medium in number and vigor, healthy, not very productive. Leaves medium to below in size, light green; leaf stems of average length, moderately slender. Fruit stems short, slender, usually double, prostrate. Blooms and ripens early, does not pick easily. Calyx small, not leafy, often discolored, sunken. Seeds numerous, depressed. Fruit above medium to small, roundish conic, often blunt at apex, attractive dark scarlet when well ripened. Flesh well colored, firm, rather tart, hardly good in flavor or quality. Color and shape quite similar to smaller berries of Rough Rider. Although early, size too small for commercial purposes.

Fairfield.—(M. Crawford Co., Cuyahoga Falls, O.) Perfect. A chance seedling found in an old peach orchard by Martin Johnson of New Jersey, previous to 1900. Introduced in the spring of 1902 by the West Jersey Nursery. Plants medium in number, rather vigorous, healthy, unproductive. Leaves medium to above in size, light green; leaf stems inclined to long and slender. Fruit stems short to medium, variable in thickness, usually double, prostrate. Blooms and ripens early, picks easily. Calyx rather large, reflexed, attractive color. Seeds numerous, medium sunken to somewhat raised. Fruit large at first pickings, drops rapidly to small as the season advances, roundish conic to slightly elongated, often sharp pointed, surface of large berries furrowed, attractive light to dark scarlet. Flesh well colored, medium to firm, mildly acid, lacking somewhat in flavor and quality, ranks no more than fair. Slightly earlier than Excelsior or Oaks Early. Somewhat less vigorous than Oaks Early. On account of earliness may have some value although undesirable in flavor and productiveness.

Florella.— (M. Crawford Co., Cuyahoga Falls, O.) Perfect. Originated in 1896 by J. P. H. Brown, Augusta, Georgia. Parent-

age, a cross between Bubach and Lady Thompson. Mr. Brown distributed plants among nurserymen and others in 1904. Plants few, medium in vigor, healthy, unproductive. Leaves above medium in size, moderately dark green; leaf stems short to medium, inclined to slender. Fruit stems short, thick, branched, prostrate. Blooms and ripens early, picks easily. Calyx medium to large, rather leafy, usually an attractive green, flat to slightly sunken. Seeds variable in depth. Fruit variable in size, roundish conic to wedge or sometimes elongated, medium dark glossy scarlet. Flesh medium red, rather firm, somewhat acid, not high in flavor, fair to good. Not equal to best varieties.

Gem.—(Slaymaker & Son, Dover, Del.) Imperfect. Plants rather few, medium in vigor, healthy, productive. Leaves medium to large, of average color; leaf stems medium in length, inclined to thick. Fruit stems medium to long, thick, often single, semi-erect to prostrate. Blooms and ripens in midseason, picks easily. Calyx rather small, not leafy, very pale green, flat to slightly sunken. Seeds variable in depth. Fruit above medium to medium in size, decreases as the season advances, conical, often sharp pointed, unattractive light scarlet. Flesh almost white, medium firm, mild, low in flavor, of poor quality. Unpromising.

Gill.—(M. Crawford Co., Cuyahoga Falls, O.) Perfect. Originated about 1898 by E. H. Ekey, Steubenville, Ohio, and introduced by him in 1906. Thought to be a result of crossing Beder Wood and a seedling of Bubach. Plants very few, weak, unhealthy in appearance, very unproductive. Leaves medium to small, yellowish green; leaf stems of average size, short. Fruit stems short to medium, thick, double. Blooms and ripens very early, picks medium easily. Calyx small to medium, discolored, flat. Seeds slightly raised to medium. Fruit medium to small, irregular in shape, averaging roundish conic, blunt, medium dark scarlet. Flesh whitish, moderately firm, mildly acid, low in flavor, of poor quality. Undesirable as fruited here.

Gladstone.—(Ellwanger & Barry, Rochester, N. Y.) Perfect. Originated about 1893 by F. F. Merceron, Catawissa, Pa., and introduced by him a few years later. Said to be a seedling of Sharpless. Plants rather few in number, vigorous, healthy, below medium in productiveness. Leaves medium to large, of medium color; leaf stems inclined to long, rather slender. Fruit stems medium to long,

stout, nearly prostrate. Blooms and ripens slightly after midseason. Calyx medium to rather small, attractive in color, often raised. Seeds usually sunken. Fruit large to above medium, wedge shape, attractive medium dark scarlet. Flesh well colored, medium firm, mildly acid, quality good. Retains size well in later pickings; hardly firm enough for long shipments; attractive color.

Golden Gate.—(S. H. Warren, Weston, Mass.) Semi-perfect. Originated in 1903 by Mr. Warren, and introduced by him in 1906. Thought to be a seedling of Marshall but parentage is uncertain. Plants medium to numerous, vigorous, healthy, very productive. Leaves large, dark green; leaf stems above medium in length, thick, branched, prostrate. Blooms in midseason, ripens medium early, picks easily. Calyx large, leafy, attractive green, slightly raised to flat. Seeds numerous, raised. Fruit very large to above medium, wedge shape, often slightly inclined to a neck, attractive medium to dark scarlet, glossy. Flesh variable in color, very firm, mildly acid, pleasant flavor but not high, quality good. Has many qualities to commend it.

Good Luck.—(W. F. Allen, Salisbury, Md.) Perfect. Introduced by Mr. Allen. Plants medium to below in number, very vigorous, healthy, below medium in productiveness. Leaves large, medium dark green; leaf stems long, medium to slender. Fruit stems medium to very long, thick, double, prostrate to semi-erect. Blooms late, ripens in midseason, picks easily. Calyx medium to large, leafy, attractive green, flat. Seeds numerous, raised. Fruit large to above medium, retains size well as season advances, blunt wedge to roundish conic, attractive medium dark scarlet. Flesh medium red, firm, sprightly acid, pleasant flavor, good to very good. Worthy of more extended trial.

Gov. Rollins.—(M. Crawford Co., Cuyahoga Falls, O.) Perfect. Originated from seed sown about 1900 by Benj. M. Smith, Beverly, Massachusetts. Introduced in 1906 by J. T. Lovett, Little Silver, New Jersey. Parentage unknown. Plants medium in number, rather vigorous, healthy, above medium in productiveness. Leaves inclined to large, dark green; leaf stems medium to long, somewhat slender. Fruit stems short to medium, thick, often double, semi-erect. Blooms and ripens in midseason, picks medium easily. Calyx very large, leafy, rather dark green, sometimes discolored, flat to slightly raised. Seeds numerous, raised. Fruit

large to above medium, retains size well till close of season, decidedly variable in first pickings, improving later, varies from coxcomb to wedge or roundish conic, surface irregularly furrowed, dull medium to dark scarlet. Flesh good color, firm, mildly acid, pleasant flavor, good to very good. Requires care in picking to avoid green tips. General appearance somewhat seedy. Worthy of more extended trial.

Great Scott.—(S. H. Warren, Weston, Mass.) Imperfect. Originated in 1902 by John Scott, Newton, Massachusetts. Introduced in 1904 by Mr. Warren. A hand pollenized seedling of Bubach and Belmont. Plants few, below medium in vigor, healthy, unproductive. Leaves of medium size, light green; leaf stems below medium in length, slender. Fruit stems short to medium, variable in thickness, often double, prostrate. Blooms and ripens in midseason, picks easily. Calyx medium in size, not leafy, reflexed, decidedly sunken. Seeds sunken. Fruit very large to medium, retains size well in later pickings, roundish conic to decided wedge, sometimes double, light to dark glossy scarlet. Flesh medium red, firm, considerably acid, not high in flavor, poor to fair in quality. Berries strongly and characteristically flattened. Surpassed by other varieties.

Helen Gould.—(M. Crawford Co., Cuyahoga Falls, O.) Imperfect. Originated by J. R. Peck, Breckenridge, Missouri, about 1896. Introduced in the spring of 1907 by the Crawford Company. It is a seedling of Jewell fertilized by Jessie. Plants very few, not vigorous, healthy, unproductive. Leaves small to medium, moderately light green; leaf stems short, slender to medium. Fruit stems very short, thick, double, prostrate. Blooms and ripens in midseason, picks rather easily. Calyx of average size, unattractive in color, flat. Seeds sunken to medium. Fruit above medium to medium in size, roundish conic to blunt wedge, dull, dark scarlet. Flesh dark red, firm, agreeably acid, pleasant flavor, fair to good. Unattractive in general appearance.

Hummer.—(W. F. Allen, Salisbury, Md.) Perfect. Introduced by Mr. Allen. Plants numerous, vigorous, slight amount of leaf blight, above medium in productiveness. Leaves large to very large, dark green; leaf stems above medium in length, thickish. Fruit stems medium to long, thick, usually branched, somewhat erect. Blooms in midseason, ripens slightly after midseason, picks easily.

Calyx medium to large, leafy, sometimes discolored, reflexed, usually slightly raised. Seeds somewhat sunken. Fruit very large to medium, varies from irregular wedge to roundish conic or slightly elongated, surface of large berries irregularly furrowed, dull light and dark scarlet. Flesh light colored, medium to firm, mild, of fair quality. Unattractive in color and shape. Variable in size throughout the season.

Hundred Dollar.—(L. J. Farmer, Pulaski, N. Y.) Perfect. Plants few, vigorous, healthy, very productive. Leaves large, medium dark green; leaf stems medium to above in length, medium to slender. Fruit stems rather long, slender, often branched. Blooms and ripens in midseason, picks easily. Calyx medium to large, rather leafy, attractive green, flat. Seeds sunken. Fruit large to medium, retains size well as season advances, wedge to roundish conic, light and dark scarlet. Flesh medium red, firm, mild, pleasant but not high flavor. Slightly coarse in appearance. Lacks in juiciness.

***Joe.**—(J. H. Black, Son & Co., Hightstown, N. J.) Perfect. Originated by Black, Son & Company, fruiting for the first time in 1893, and introduced by them in 1899. A seedling of Middlefield and Chairs was crossed with Sharpless and one of the best seedlings obtained in this way was crossed with Gandy. The most promising of this cross was named Joe. Plants few, vigorous, healthy, productive when planted closer than most varieties. Leaves medium to very large, medium dark green; leaf stems long, thick. Fruit stems long, thick, usually double, semi-erect. Blooms late, ripens in midseason or slightly later, picks easily. Calyx averages medium in size but often large, rather leafy, usually flat. Seeds numerous, raised. Fruit above medium to very large, blunt, roundish conic or irregular wedge, surface often furrowed, attractive glossy dark scarlet. Flesh dark red, very firm, agreeably acid, high in flavor, very good in quality. On account of making few runners the plants should be set closer than most varieties. Has many qualities that commend it, especially large size of fruit which is well retained as the season advances, attractive color, and desirable flavor and quality. Requires care in picking to avoid green tips.

Kansas.—(W. F. Allen, Salisbury, Md.) Imperfect. Originated in 1899 by J. J. Wittman, Emporia, Kansas, and introduced

*Plants were set 3 ft. x 10 inches.

by Mr. Allen in the spring of 1900. Said to be chance seedling of unknown parentage. Plants medium to numerous, of average vigor, uninjured by leaf blight, productive. Leaves medium in size, rather pale green; leaf stems of fair length, inclined to slender. Fruit stems medium long, thick, usually single. Blooms and ripens slightly after midseason. Calyx large, leafy, usually in a depression. Seeds slightly raised. Fruit averages above medium to medium in size, decreases as the season advances, roundish conic to slight wedge, rather blunt, apex frequently ends in a depression, surface often irregularly furrowed, attractive medium dark scarlet. Flesh well colored, firm, juicy, mild acid, good to very good. Fruit average slightly larger than in 1906 although too small for those markets requiring large size. With this exception it has many qualities that commend it to growers.

King Edward. — (D. J. Miller, Millersburg, O.) Perfect. Originated by Mr. Miller in 1903, fruiting for the first time in 1904. Not yet introduced. A seedling of the Miller. First named King but later changed to King Edward. Plants moderately numerous, somewhat lacking in vigor, healthy, very productive. Leaves of average size, moderately dark green; leaf stems medium to above in length, medium to thick. Fruit stems below average length, thick, usually single. Blooms and ripens in midseason. Calyx medium size, not depressed but sometimes on a slight neck. Seeds raised. Fruit above medium to medium in size, inclined to roundish conic or slight wedge, rather unattractive light scarlet. Flesh somewhat light in color, firm, mild, sweetish, agreeable flavor, good in quality. The berries are not well protected from the sun and drop rapidly in size as the season advances, running too small for a desirable commercial variety.

Klondike.—(W. F. Allen, Salisbury, Md.) Perfect. Originated by R. L. Cloud, Independence, Louisiana. Plants few to medium, somewhat vigorous, healthy, unproductive. Leaves medium to large, rather dark green; leaf stems inclined to long, of average size. Fruit stems rather long and thick, often single, somewhat erect. Blooms in midseason, ripens slightly before midseason, picks easily. Calyx medium to large, reflexed, strongly tinged with dull red, flat to slightly sunken. Seeds variable in position. Fruit large to medium, retains size as the season advances, blunt, roundish conic to slight wedge, dark, dull, unattractive scarlet. Flesh dark red, very firm, decidedly acid, unpleasant flavor, poor in quality. Undesirable as grown here.

Latest.—(Flansburgh & Potter, Leslie, Mich.) Imperfect. Originated in 1895 by S. H. Warren, Weston, Massachusetts, and introduced by him in 1900. It is a seedling obtained by crossing Jewell and Belmont. Plants with few if any runners, of medium vigor, healthy, below medium in productiveness Leaves medium to below in size, of average greenness; leaf stems somewhat short, slender. Fruit stems short to medium, of fair thickness, semi-prostrate, not well protected from the sun. Blooms in midseason, ripens slightly after midseason, picks easily. Calyx medium to above in size, rather leafy, slightly raised. Seeds slightly sunken. Fruit large to medium, very irregular in shape, unattractive light and dark dull scarlet. Flesh whitish, moderately firm, mildly acid, of fair quality. Undesirable in shape and unattractive in color.

Magnus.—Originated on Station grounds in 1899 and disseminated by this Station in the spring of 1908. Parentage, Hunn X Marshall. The following description is taken from Bulletin No. 298 (March, 1908) of this Station supplemented by notes taken during the past season. Blossoms imperfect. Plants medium to numerous, medium to above in height, productive. Leaves large, attractive dark green, attacked slightly by leaf blight in unfavorable seasons; leaf stems medium in length, thick. Fruit stems of average length, variable in thickness, usually double, prostrate. Blooms late, ripens in midseason, picks easily. Calyx large and leafy, dark green, set in a slight depression. Seeds raised, often dark colored. Fruit above medium to very large, retains its size well as the season advances, roundish conic to slightly elongated and with pointed apex, light to very dark scarlet, showing Hunn blood, variable in color unless well ripened. Flesh rather light at center, firm, juicy, mildly acid, good to very good flavor and quality. The growth and color of foliage closely resemble Marshall, while the color of the fruit is that of the Hunn. When well colored, this variety ranks among the very best in size, attractiveness, and quality. It is thought that the Magnus will prove a very valuable new sort for home use. Its variable color is somewhat against it for the market. One of the most attractive of over fifty varieties fruited in 1908.

Mark Hanna.—(M. T. Thompson, Rio Vista, Va.) Imperfect. A seedling of Bubach originated by Mr. Thompson in 1898 and introduced by him in 1902. Plants numerous, vigorous, healthy, productive. Leaves of medium size and color; leaf stems medium to long, thickish. Fruit stems long, thick, usually double. Blooms

late in midseason, ripens in midseason, picks easily. Calyx of medium size, usually reflexed. Seeds numerous, sunken. Fruit large, retains good size until close of season, irregular in shape varying from coxcomb or wedge to roundish conic, surface often irregularly furrowed, attractive light scarlet, glossy. Flesh of fairly good color, medium firm, juicy, agreeably tart, fair to good in quality. May have value where highest quality is not the first requisite. The general appearance of the largest berries is slightly coarse.

Marshall.—(From bed in Station grounds.) Perfect. Originated in 1890 and introduced in 1893 by M. F. Ewell, Marshfield Hills, Massachusetts. Plants only medium in number, medium to vigorous, considerably injured by leaf blight, rather unproductive. Leaves somewhat large, light to dark green; leaf stems of fair length, thick. Fruit stems medium in length, stout, usually double, prostrate. Blooms and ripens in midseason, picks easily. Calyx of medium size, sligthly discolored, somewhat depressed. Seeds slightly raised. rather large. Fruit very large to above medium when well grown, otherwise varying to below medium, roundish conic to wedge, surface often irregularly furrowed, attractive dark scarlet. Flesh well colored, firm, juicy, pleasant acid, of high flavor, good to very good. Unless well ripened, berries inclined to have greenish tips. A standard commercial variety variable in certain locations, not succeeding generally. Requires high culture.

***Mead.**—(J. H. Hale, South Glastonbury, Conn.) Perfect. Originated with O. E. Mead, Lunenberg, Massachusetts, about twelve years ago. Introduced to the trade by Mr. Hale in spring of 1904. Parentage unknown. Plants medium to below in number, rather vigorous, healthy, very productive. Leaves medium to large, dark green; leaf stems medium to above in length, of average thickness. Fruit stems variable in length and thickness, usually double, nearly prostrate. Blooms in midseason, ripens slightly after midseason, picks easily. Calyx medium to above in seize, somewhat leafy, attractive color, flat to slightly sunken. Seeds variable in depth. Fruit very large to medium, roundish conic, very blunt, sometimes flattened or roundish, surface smooth, attractive light and dark glossy scarlet. Flesh good color, medium to firm, mildly acid, pleasant flavor, very good in quality. Good size of

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*Plants were set 3 ft. x 10 inches.

fruit in late pickings. Attractive. Varies somewhat in firmness. Should be planted closer than most varieties.

Millionaire.—(The American Agriculturist, New York City.) Imperfect to semi-perfect. Originated by Henry Jerolaman, Hilton, New Jersey, in 1892. Not yet introduced to the trade. It is a cross between Hilton Gem and Mary. The following description was made from plants set in the fall of 1907: Plants vigorous, healthy, appear productive. Leaves very large, attractive dark green; leaf stems medium to above in length, thick. Fruit stems medium to long, thick, prostrate, often single. Blooms very late, ripens in late midseason, picks easily. Calyx medium to above in size, flat to slightly depressed. Seeds numerous, raised. Fruit large to above medium, variable in shape ranging from somewhat flattened to irregular conic, inclined to wedge, light scarlet. Flesh medium red, firm, agreeably acid, not high in flavor, of fair quality. Requires further testing to fully determine value but up to the present time does not appear to equal the best standard sorts.

Miss Boston.—(J. H. Hale, South Glastonbury, Conn.) Imperfect. Plants few, medium to below in vigor, healthy, productive. Leaves rather small, medium dark green; leaf stems short to medium, inclined to slender. Fruit stems rather short, thick, often double, prostrate. Blooms in midseason, ripens medium early, picks moderately easily. Calyx large to medium, leafy, reflexed, pale green, flat to slightly sunken. Seeds variable in depth. Fruit large to medium, dropping to small as the season advances, attractive roundish conic to slight wedge, light to dark scarlet. Flesh good color, medium to firm, agreeably acid, only moderately juicy, fair to good. Fruit has many desirable characters. Plants lack somewhat in vigor.

Morning Star.—(M. Crawford Co., Cuyahoga Falls, O.) Perfect. Originated about 1898 by M. T. Thompson, Rio Vista, Virginia, and introduced in 1904 by J. T. Lovett Co., Little Silver, New Jersey. Plants few in number, not very vigorous, healthy, very unproductive. Leaves medium to below in size, light green; leaf stems short to medium, slender. Fruit stems short, slender to medium, usually double, prostrate. Blooms early, ripens in midseason, does not pick easily. Calyx medium to large, often discolored. Fruit small to above medium, roundish conic, dark scarlet. Flesh well colored, firm, mild, pleasant flavor, good quality. Plants unproductive and fruit too small.

Mrs. Miller.—(M. Crawford Co., Cuyahoga Falls, O.) Imperfect. Originated in 1893 by D. J. Miller, Millersburg, Ohio. Introduced in the spring of 1905 by M. Crawford Company. Parentage unknown. Plants medium in number, moderately vigorous, slightly injured by leaf blight, below medium in productiveness. Leaves of average size and color; leaf stems short to medium, variable in thickness. Fruit stems of medium length, thick, often single, prostrate. Blooms medium early, ripens in midseason. Picks moderately easily. Calyx large to medium, leafy, slightly discolored, usually not sunken. Seeds somewhat depressed. Fruit large to medium, decreases rapidly in size in later pickings, varies in shape from wedge to roundish conic or slightly elongated, surface uneven, dark scarlet. Flesh well colored, nearly firm, agreeably acid, quality good. The discolored calyx detracts from appearance and the fruit runs too small in later pickings.

Nehrings Gem.—(M. Crawford Co., Cuyahoga Falls, O.) Imperfect. Originated at Strasburg, Illinois, in 1891 by W. F. Nehring, who moved to Milo, Missouri, the following year. Introduced by the Crawford Company in 1906. Plants not numerous, vigorous, healthy, not very productive. Leaves large to very large, rather dark green; leaf stems long, quite thick. Fruit stems short to medium, thick, usually branched, prostrate. Blooms and ripens in midseason, picks medium easily. Calyx large, leafy, often reflexed, decidedly sunken, often discolored in later pickings. Seeds slightly raised. Fruit above medium to large, drops in size in later pickings, usually roundish conic, sometimes irregular wedge, attractive dark scarlet. Flesh fairly well colored, firm, agreeably acid, quality good to very good. Plants should be set closer to secure good yields. Size variable in late pickings. Fairly good showing.

Nettie.—)J. H. Black, Son & Co., Hightstown, N. J.) Imperfect. Originated in 1893 by Black, Son & Co., and introduced by them in 1899. A seedling of Bubach and Yale was crossed with Sharpless. One of the resulting seedlings was crossed with Gandy. This gave Nettie. Plants medium to rather numerous, vigorous, healthy, productive. Leaves large, attractive, dark green; leaf stems long, rather thick. Fruit stems long, thick, often single, inclined to erect. Blooms and ripens late, picks easily. Calyx medium to large, leafy, attractive green, slightly raised. Seeds usually sunken. Fruit very large to above medium, roundish conic or wedge to slightly

Plate XL.— Strawberry Test Plats in 1908, Above; Portion of Row of Columbia, Below.

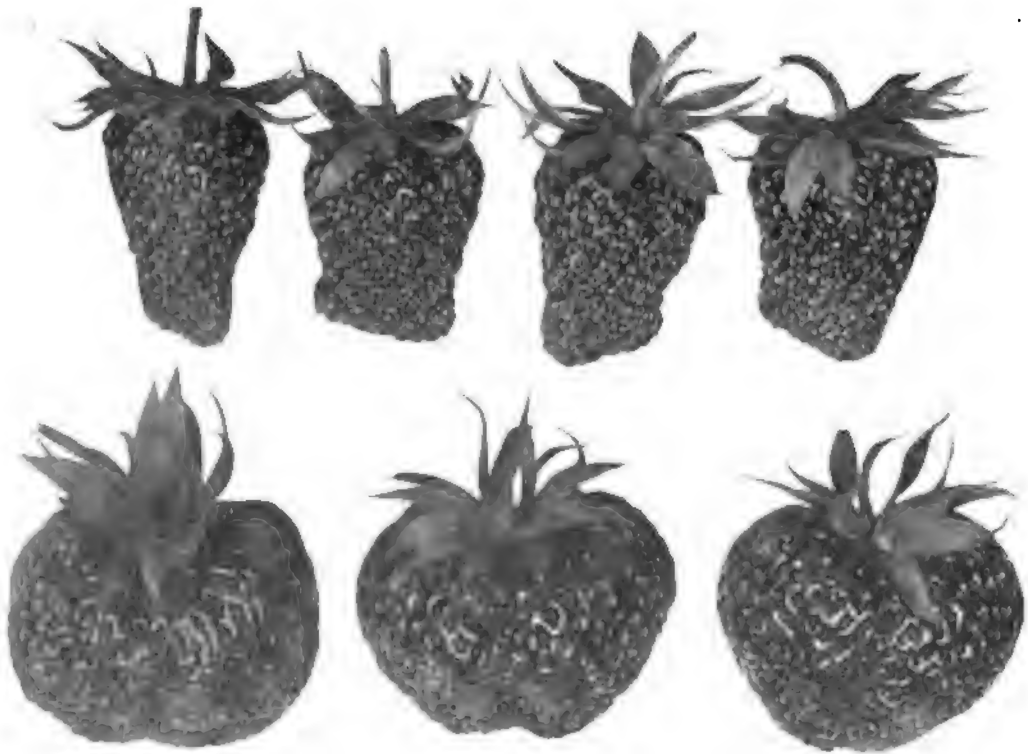
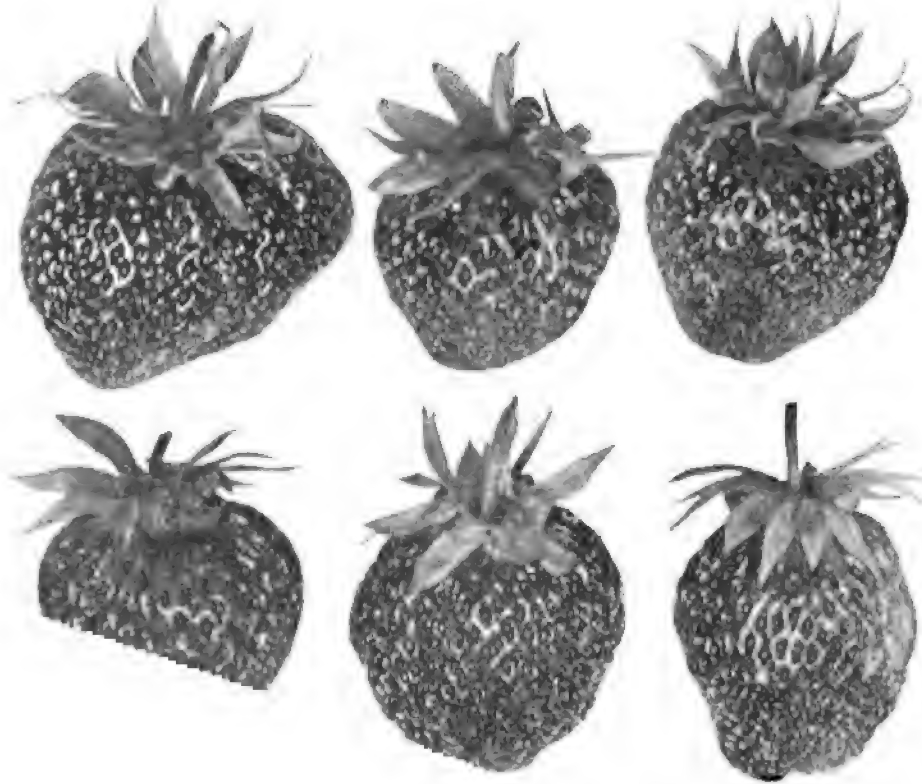


PLATE XLI.—ADVANCE, ABOVE; AMANDA, BELOW.
(Natural Size.)



...E; ELMA, BELOW.

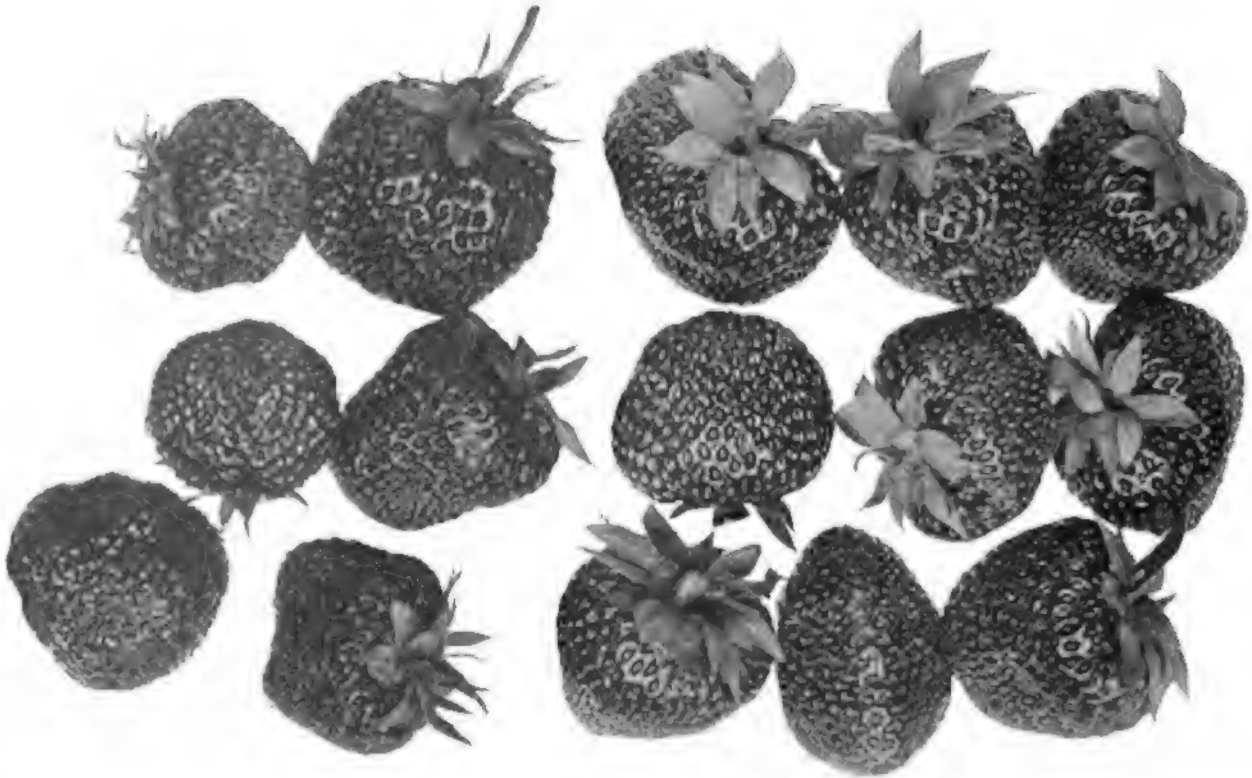


Plate XLIV.— President, at Left; Chesapeake, at Right.
(Natural Size.)

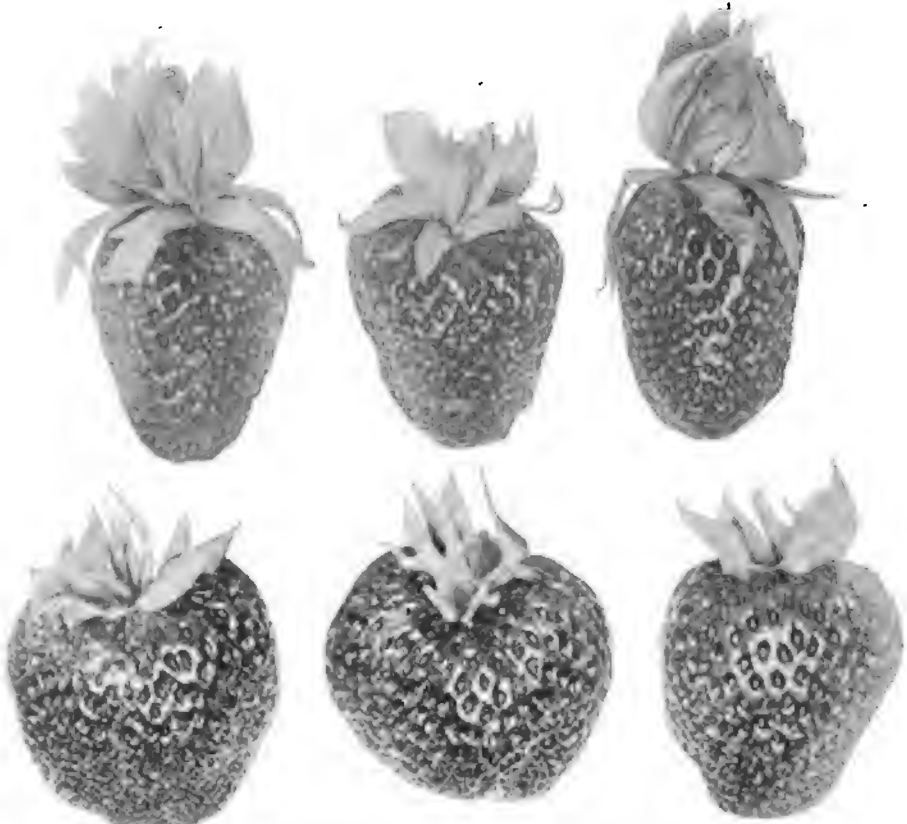


Plate XLV.— Quality, Above; Joe, Below.

elongated, rather dull, light to medium scarlet. Flesh of fair color, medium to firm, rather acid, not high in flavor, no more than good in quality. Resembles Prof. Fisher in general appearance but is earlier. A rather showy late variety, not of highest flavor or quality.

New Globe.—(W. F. Allen, Salisbury, Md.) Perfect. Plants medium in number and vigor, susceptible to attacks of leaf blight, very productive. Leaves medium to above in size, rather dark green; leaf stems of average length, thick. Fruit stems medium to long, thick, often double, somewhat erect. Blooms and ripens in midseason, picks medium easily. Calyx large to medium, often leafy, discolored, flat. Seeds sunken. Fruit large to below medium, decreasing as the season advances, very irregular in shape averaging roundish conic, surface unusually roughened and furrowed, unattractive dull medium scarlet. Flesh rather light, firm, considerable acid, not high in flavor, fair in quality. Coarse and unattractive in general appearance. The fruit-bud clusters before opening are conspicuous, showing above the foliage.

New Home.—(W. F. Allen, Salisbury, Md.) Perfect. Plants rather few, medium in vigor, healthy, unproductive. Leaves medium to below in size, light green; leaf stems of average length, slender. Fruit stems medium to long, thick, usually double, somewhat erect. Blooms in midseason, ripens slightly past midseason, picks easily. Calyx large, leafy, attractive green, slightly sunken. Seeds raised, terminating in short dark hairs which seem characteristic. Fruit averages above medium in size, decreasing as the season advances, roundish conic, often depressed at apex, attractive light scarlet, some berries dark scarlet. Flesh fairly good color, very firm, mildly acid, fair in quality. Attractive in shape and color, a good shipper but deficient in size in late pickings. Plants set closer than most varieties.

Nimrod.—(M. Crawford Co., Cuyahoga Falls, Ohio.) Perfect. Originated about 1898 by John F. Beaver, Dayton, Ohio, and introduced the fall of 1904 by the Crawford Company. Plants few in number, not vigorous, low in height, susceptible to attacks of leaf blight, very unproductive. Leaves of average size and color; leaf stems short and slender. Fruit stems very short, slender, often single. Blooms medium early, ripens slightly before midseason, does not pick easily. Calyx medium to rather large, often discolored, in-

clined to leafy, usually not sunken. Seeds raised, numerous. Fruit above medium to small, roundish conic, blunt, attractive light and dark scarlet. Flesh fairly good color, very firm, agreeably acid, good in quality. The plants lack in vigor and productiveness while the fruit runs too small for commercial purposes.

North Shore.—(W. F. Allen, Salisbury, Md.) Perfect. Originated in 1898 by Wm. H. Monroe, Beverly, Massachusetts, and introduced about 1902. A seedling of Brandywine. Plants few in number, moderately vigorous, susceptible to attacks of leaf blight, not productive. Leaves of medium size and color; leaf stems short to medium, variable in thickness. Fruit stems short, usually thick, often single, prostrate. Blooms late in midseason, ripens slightly after midseason. Calyx large, leafy. Seeds slightly raised. Fruit large to medium, irregular in shape varying from wedge to roundish conic, rather dark dull scarlet. Flesh good firm color, mildly acid, pleasant flavor, good to very good in quality. Although of desirable flavor and quality, not equal to standard kinds as the plants are unproductive and subject to attacks of fungi. Color unattractive at first pickings but improves as the season advances.

Oaks Early.—(W. F. Allen, Salisbury, Md.) Perfect. Found growing wild on William Tull's farm, Maryland. Plants medium in number, vigorous, healthy, below medium in productiveness. Leaves rather large, dark green; leaf stems long, usually thick. Fruit stems medium to long, thickish, double, semi-erect. Blooms and ripens early, picks easily. Calyx large, rather leafy, often with a reddish tinge, slightly raised. Fruit above medium to medium in size, decreasing as the season advances, slightly elongated and with pointed apex, moderately attractive light to dark scarlet. Flesh well colored, firm, agreeably acid, quality fair to good. Plants more vigorous than Excelsior; too many small berries in later pickings.

Olympia.—(Woodlawn Nurseries, Rochester, N. Y.) Perfect. Plants few in number, moderately vigorous, susceptible to attacks of leaf blight, very unproductive. Leaves of average size and color; leaf stems medium to above in length, rather slender. Fruit stems short to medium, moderately thick, usually double, erect. Blooms medium early, ripens in midseason, picks easily. Calyx medium to above in size, often discolored, slightly depressed to flat, detaches readily from fruit in picking. Seeds raised, dark colored. Fruit varies from large to small, roundish conic, broad at

base, apex blunt, light scarlet. Flesh light colored, juicy, firm, rather acid, not high in flavor or quality. Although there are many large berries in the later pickings, the appearance is unattractive on account of the light color and the detached calyx. Surpassed in quality by standard kinds.

Omega.—(A. V. Metcalf, Brunswick, Maine.) Perfect. Originated in 1904 by Mr. Metcalf. Has not yet been introduced. A chance seedling found in an asparagus bed. Plants medium in number and vigor, considerable leaf blight, productive. Leaves medium to large, dark green; leaf stems short to medium, inclined to slender. Fruit stems not long, often single, somewhat erect. Blooms and ripens in midseason, picks medium easily. Calyx medium to large, sometimes leafy, attractive green, flat to sometimes slightly raised. Seeds raised. Fruit large to medium or below in later pickings, wedge to roundish conic, attractive medium to dark scarlet. Flesh good color, firm, quite acid, rather pleasant flavor, fair to good. Fairly good showing but appears subject to leaf blight.

Oneida.—(Isaac Hildreth, Rome, N. Y.) Perfect. Originated in 1903 by Mrs. Hildreth. Not yet introduced. A seedling of Sharpless. Plants very numerous, vigorous, nearly free from leaf blight, very productive. Leaves medium to above in size, rather dark green; leaf stems medium to long, slender. Fruit stems usually long, moderately thick, inclined to double. Blooms and ripens in midseason. Calyx large to medium, often leafy, usually not depressed, sometimes on a slight neck. Seeds sunken. Fruit variable in size, very large to medium, roundish conic to blunt wedge or sometimes slightly elongated, irregularly furrowed, light and dark scarlet. Flesh rather light, firm, aromatic, not very jucy, mild, fair to good in quality. Although the fruit retains its desirable size during the late pickings, the general appearance is rather coarse and unattractive, and the flesh lacks in juiciness, flavor and in high quality.

Oswego.—(L. J. Farmer, Pulaski, N. Y.) Perfect. Introduced in 1906 by L. J. Farmer, Pulaski, N. Y. Said to be a cross of Bubach fertilized by Sharpless. Plants few, vigorous, healthy, very productive. Leaves very large, dark green; leaf stems medium to long, inclined to slender. Fruit stems short to medium, very thick, double, prostrate. Blooms in midseason, ripens slightly before midseason, picks easily. Calyx of medium size, not very leafy, medium

green, variable in position. Seeds sunken to medium, often dark colored. Fruit large, dropping to small as the season advances, roundish conic to wedge, surface often furrowed, dark scarlet. Flesh light red, variable in firmness, mildly acid, not high in flavor, quality good. Surpassed by other varieties.

Pineapple Flavored.—(Greens Nursery Company, Rochester, N. Y.) Perfect. Originated by Mr. Talmage, Mt. Morris, N. Y., about 1896. Introduced by Greens Nursery Company about 1902. A chance seedling. Not the variety described by this Station in 1889 under the name of Pineapple. Plants very numerous, vigorous, slight amount of leaf blight, above medium in productiveness. Leaves medium to large, of average color; leaf stems rather long, inclined to slender. Fruit stems medium to very long, of average thickness, often double, prostrate. Blooms in midseason, ripens slightly before midseason, picks easily. Calyx medium to small, not reflexed, often discolored, flat to slightly raised. Seeds raised. Fruit above medium to small, blunt, roundish conic, attractive medium to dark scarlet. Flesh rather light, very firm, of medium acidity, well flavored, fair to good in quality. Berries inferior in size. Attractive in shape and color.

President.— (Slaymaker & Son, Dover, Del.) Imperfect. Originated about 1900 by M. R. Hunt, Lambertville, N. J. Plants medium to numerous, vigorous, somewhat injured by blight, productive. Leaves large, dark green; leaf stems long, thick. Fruit stems medium to long, thick, usually double, inclined to prostrate. Blooms and ripens in midseason, picks easily. Calyx rather large, leafy, often slightly tinged with pink, flat. Seeds slightly depressed. Fruit of largest size, roundish conic, blunt, slightly furrowed, occasionally flattened, attractive bright scarlet. Flesh medium light color, firm, moderately juicy, mild, fair to good in quality. One of the largest and most attractive varieties in the Station collection but somewhat deficient in flavor and not of high quality. One of the most promising varieties where size and color are prime requisites. Growers report that plants not true to name are being sold as President. The sex of the blossom is one of the distinguishing characters.

Pres. Roosevelt.— (L. J. Farmer, Pulaski, N. Y.) Imperfect. Originated and introduced by A. Y. Cathcoit, Bristol, Indiana. A seedling of Warfield X Clyde. Plants not very numerous, vigorous,

slightly injured by leaf blight, below medium in productiveness. Leaves of average size, medium dark green; leaf stems above medium in length, slender. Fruit stems short to medium, often slender, strongly branched, prostrate. Blooms in midseason, ripens early, picks easily. Calyx large to medium, reflexed, discolored, often raised on a long neck. Seeds variable in depth, often dark colored. Fruit above medium to small, irregular in shape, often elongated but varying to roundish, strongly necked, surface irregularly furrowed, medium to dark glossy scarlet. Flesh of good color, medium firm, agreeably acid, pleasant flavor, quality good. Hulls detach readily. Berries too small.

***Prof. Fisher.**— (Geo. R. Schauber, Ballston Lake, N. Y. Imperfect. Originated by J. H. Black, Son & Co., Hightstown, New Jersey, and introduced by them in 1899. A seedling obtained by fertilizing Bubach with Sharpless was crossed with Brandywine. One of the resulting seedlings was named Prof. Fisher. Plants few, should be set closer than most varieties, vigorous, healthy, productive. Leaves very large, attractive dark green; leaf stems medium to slender, rather long. Fruit stems medium to long, semi-erect, often single, medium to slender. Blooms and ripens late, picks easily. Calyx medium to below in size, not leafy, often raised on a swollen neck. Seeds usually sunken. Fruit large, retains size well throughout the season, irregular wedge, surface furrowed, light scarlet. Flesh medium red, moderately firm, rather acid, not high in flavor, fair to good. Coarse in appearance, decidedly tart, large, late. Productive.

Prolific.— Originated on Station grounds in 1899 and disseminated by this station in 1908. Parentage, Sample X Marshall. The following description is taken from Bulletin No. 298 (March, 1908) of this Station supplemented by notes taken during the past summer. Blossoms perfect. Plants very numerous, vigorous, unusually productive, yielding on the Station grounds as high as 14,502 quarts per acre. Foliage of good size, somewhat susceptible to leaf blight in unfavorable seasons, in color comparatively dark green; leaf stems long, thick. Fruit stems of medium length, stout and usually single, semi-erect. Blooms and ripens in midseason, picks easily. Calyx medium to below in size, not leafy, depressed to flat. Seeds numerous to somewhat raised. Fruit very large to above

*Plants were set 3 ft. x 10 inches.

medium, retains size well as the season advances, roundish conic to blunt wedge, rather light in color but nevertheless an attractive bright scarlet. Flesh firm, fairly good color at center, agreeably acid and of good flavor and quality. The color of fruit is slightly lighter than Marshall, possibly a merit for some markets. On account of its vigor, the great productiveness of its plants, and the attractiveness of the large, well colored berries, this variety gives promise of taking front rank among standard commercial strawberries.

Quality.—Originated on Station grounds in 1899 and disseminated by this Station in the spring of 1908. Parentage, Hunn X Atlantic. The following description is taken from Bulletin No. 298 (March 1908) of this Station supplemented by notes taken during the past summer. Blossoms variable, averaging semi-perfect. Plants numerous, usually fairly productive, somewhat injured by leaf blight, of average vigor. Leaves medium to large, dark green; leaf stems medium to below in length, rather stout. Fruit stems variable in length, stout, usually double, semi-erect. Blooms and ripens late, picks easily. Calyx medium to large, leafy, set in a slight depression or sometimes slightly raised, attractive green. Seeds sunken to slightly raised. Fruit above medium to very large, roundish conic to wedge, or varying to slightly elongated but blunt at apex, often necked, light and dark scarlet, glossy. Flesh good color to center of fruit, firm, mildly acid, good to very good in flavor and quality. Both plant and berry of Quality resemble the Hunn more than the Atlantic. It is also variable in sex. On the Station grounds it ranges through all gradations from perfect to imperfect. In 1908 there was a marked variation in shape and color of fruit, many berries assuming a dull, unattractive color and also appearing less promising in flesh characters. The type evidently does not appear to be fixed.

Ridgeway.—(From bed in Station grounds.) Perfect. Originated and introduced some years ago by M. H. Ridgeway of Indiana. Plants numerous, somewhat vigorous, healthy, productive. Leaves medium to above in size, light to dark green; leaf stems medium to above in length, variable in thickness. Fruit stems short, stout, usually double, prostrate to semi-erect. Blooms in midseason, ripens slightly after midseason, picks easily. Calyx large, leafy, attractive green, detaches readily from berry, flat to slightly raised. Seeds slightly sunken to raised. Fruit averages above medium in size, roundish or roundish conic to slight wedge, blunt pointed,

smooth surface, attractive light scarlet, often glossy. Flesh fair color, medium firm, juicy, good in quality. Not as good a shipper as some standard kinds. The calyx detaches readily in picking. Retains size in later pickings fairly well.

Riehl No. 28.—(E. H. Riehl, North Alton, Ill.) Perfect. Originated in 1895 by Mr. Riehl. It has not been introduced.. A seedling of Brandywine crossed with Ruby. Plants numerous, above medium in vigor, susceptible to attacks of leaf blight, productive. Leaves medium to large, of average color; leaf stems medium in length and thickness. Fruit stems intermediate in length, thick, semi-erect. Blooms in midseason, ripens early, picks medium easily. Calyx large, leafy, slightly reflexed, attractive green, flat to slightly sunken. Seeds numerous, slightly raised to medium. Fruit large to medium, dropping to small in late pickings, blunt, roundish conic to wedge, attractive dark scarlet. Flesh medium dark red, very firm, rather sweet, mild, good to very good. Has many qualities to commend it, but the plants suffer from fungi and berries run small towards close of season.

Rough Rider.—(L. J. Farmer, Pulaski, N. Y.) Perfect. Said to be a cross of Bubach and Gandy originated in 1893 by Chas. Learned, and introduced in 1900 by L. J. Farmer. Plants medium in number, moderately vigorous to vigorous, slightly attacked by leaf blight, below medium in productiveness. Leaves of medium size and color; leaf stems above medium in length, rather slender. Fruit stems of fair length, variable in thickness, usually double. Blooms slightly past midseason, ripens rather late, picks easily. Calyx medium to below in size, rather leafy, often reflexed, sunken. Seeds depressed. Fruit large to above medium, retains good size through the season, wedge to roundish conic, rather dark attractive scarlet. Flesh well colored to center, firm, agreeably acid, pleasant flavor, quality good. A desirable late variety on account of size, attractiveness and good characters of flesh.

Ruby.—(E. H. Riehl, North Alton, Ill.) Perfect. Originated in 1890 by Mr. Riehl and introduced by him in 1895. Thought to be a seedling of Crescent crossed with Sharpless. Plants medium in number and vigor, healthy, productive. Leaves small, medium light green, under surface hairy; leaf stems hairy, above medium in length, often very slender. Fruit stems variable in length, rather slender, often branched, prostrate. Blooms in midseason, ripens slightly before midseason, picks rather easily. Calyx medium to

above in size, often discolored, flat to sunken. Seeds variable in depth. Fruit variable in size ranging from large to medium, irregular wedge to roundish conic, dull, often unattractive dark scarlet. Flesh well colored to center, firm, agreeably acid, fairly well flavored, quality good. Dull in color and too dark for most markets. Surpassed by other kinds.

Ryckman.—(G. E. Ryckman & Sons, Brocton, N. Y.) Perfect. Plants moderately numerous, vigorous, healthy, productive. Leaves medium to large, rather dark green; leaf stems long, variable in thickness. Fruit stems long, slender to thick, usually double. Blooms and ripens in midseason. Calyx large to small, leafy, usually slightly raised, attractive green. Seeds depressed to slightly raised. Fruit very large to medium, roundish conic to slight wedge sometimes elongated, surface roughly furrowed, rather dull light to dark scarlet. Flesh medium light colored, firm, mild, not juicy, not high in flavor, fair to good in quality. The fruit is coarse in general appearance and not uniform in size, while the flavor and quality are surpassed by other varieties of the same season.

St. Louis.—(J. A. Bauer, Judsonia, Ark.) Perfect. Originated in 1904 and introduced in 1906 by Mr. Bauer. Grown from seed obtained by crossing Haviland with Lady Thompson. Plants of average number, vigorous, healthy, very productive. Leaves medium in size, slightly tinged with yellow; leaf stems long, slender. Fruit stems medium to long, rather slender, often double, prostrate. Blossoms in midseason, ripens early, picks very easily. Calyx large to medium, pale green, leafy, variable in position. Seeds variable in depth. Fruit large to medium, dropping to small in late pickings, variable in shape, often elongated conical, very light red. Flesh light colored, soft, of medium acidity, not high in flavor, poor in quality. Lacks character. Color unattractive. Poor shipper. above medium in length and thickness. Fruit stems short to medium, often very thick, double, somewhat prostrate. Blooms late, ripens in midseason, picks medium easily. Calyx of medium size, attractive green, flat. Seeds often deeply sunken. Fruit large to medium, retains size fairly well as season progresses, roundish to somewhat flattened, light to dark scarlet. Flesh medium red, very firm, pleasant acid, juicy, well flavored, quality good. Some berries slightly coarse in general appearance. Good shipper.

Seneca.—(L. D. Brundage, Dundee, N. Y.) Perfect. Originated in 1902 by Mr. Brundage and introduced by him in 1907. A chance

seedling of unknown parentage. Plants rather numerous, very vigorous, healthy, unproductive. Leaves medium to large, somewhat light green; leaf stems very long, medium to slender. Fruit stems of medium length, rather thick, often single, semi-erect. Blooms and ripens in midseason, picks medium early. Calyx of fair size, not leafy, pale green, raised. Seeds variable in depth, often dark colored. Fruit large to medium, dropping to small as the season advances, inclined to roundish slightly necked, very light scarlet. Flesh light color or sometimes with tinge of yellow, soft, mild, not high in flavor, no more than fair in quality. Fruit too light in color and not a firm shipper.

Senator Dunlap.—(L. J. Farmer, Pulaski, N. Y.) Perfect. Originated about 1890 by J. R. Reasoner, Urbana, Illinois, and introduced by M. Crawford, Cuyahoga Falls, Ohio, in 1899. Parentage uncertain, but possibly a seedling of Warfield. Plants very numerous, vigorous, healthy, very productive. Leaves of medium size and color; leaf stems long, slender. Fruit stems long, medium slender, usually single. Blooms in midseason, ripens slightly before midseason, picks easily. Calyx medium to nearly large, reflexed, usually on a slight neck. Seeds medium or above in size as the season advances, roundish conic to slightly elongated, often with a slight neck, glossy attractive light and dark scarlet. Flesh well colored, medium to firm, rather mild, pleasant flavor, quality good. Inclined to produce too many plants. Although somewhat variable in size, is desirable on account of general attractiveness and desirable flesh characters.

Somerset Maid.—(J. H. Hale, South Glastonbury, Ct.) Perfect. Plants medium in number and vigor, healthy, productive. Leaves small, medium dark green; leaf stems short to medium, often very slender. Fruit stems short to medium, slender to thick, often single, semi-erect to prostrate. Blooms early, ripens in midseason, picks easily. Calyx medium to above in size, not leafy, dull green, flat to slightly raised. Seeds numerous, raised slightly. Fruit above medium to small, somewhat elongated to roundish conic, surface often furrowed, medium dark scarlet. Flesh dark red, firm, agreeably acid, pleasant flavor, quality good to very good. General appearance slightly seedy. Inferior in size.

Star.—(J. G. Harrison & Sons, Berlin, Md.) Perfect. Plants few, medium in vigor, healthy, unproductive. Leaves of medium

size, light green; leaf stems short to medium, inclined to slender. Fruit stems medium to above in length, variable in thickness, often double, prostrate to semi-erect. Blooms late, ripens in midseason, picks easily. Calyx small to medium, not leafy, variable in position, discolored. Seeds raised, numerous. Fruit large to medium, retains size well as season advances, roundish conic to wedge, surface furrowed, dull, dark scarlet. Flesh dark red, firm, sweetish, mild, nearly good in quality. Tips seedy. Surpassed by better varieties.

Stevens Late Champion.—(Flansburgh & Potter, Leslie, Mich.) Perfect to semi-perfect. Originated in 1897 and introduced in 1903 by Arthur Stevens, Bridgeton, N. J. Said to be a seedling of Bayview crossed with Pride of Cumberland. Plants few in number, vigorous, healthy, very unproductive. Leaves large to very large, dark green; leaf stems above medium in length, rather thick. Fruit stems of average length, somewhat erect. Blooms and ripens in midseason, picks easily. Calyx medium to above in size, often leafy, attractive green, slightly sunken. Seeds depressed. Fruit large, retains its size well through the season, irregular in shape, varying from coxcomb to wedge and roundish conic, attractive light scarlet. Flesh fairly well colored, firm, agreeably acid, pleasant flavor, quality good. Care must be taken in picking to avoid green tips. Has many qualities which commend it. Plants should be set closer than most varieties.

"Three W."—(Flansburgh & Potter Co., Leslie, Mich.) Perfect. Originated in 1901 by W. W. Wallace, Harriman, Tennessee. Introduced by W. A. Mason, Clinton, Kentucky, in 1906. A chance seedling. Plants medium to few, below average vigor, healthy, very productive. Leaves small to medium, light green; leaf stems short, slender to medium. Fruit stems not long, very thick, double, prostrate. Blooms and ripens in midseason, picks easily. Calyx medium to large, sometimes leafy, often discolored, raised to flat. Seeds sunken to medium. Fruit large to medium, dropping in size in later pickings, elongated roundish conic, sharp pointed, very dark scarlet. Flesh dark red, medium firm, mildly acid, pleasant flavor, good in quality. Unattractive in shape. Flesh unusually dark red. Yielded at rate of 12,342 quarts per acre.

Uncle Jim.—(Flansburgh & Potter Co., Leslie, Mich.) Perfect. Originated by J. F. Dornan, Glenn, Michigan, and introduced in

1901 by Flansburgh & Potter. A chance seedling. Sometimes sold as " Dornan," from the name of the originator. Plants of medium number, vigorous, healthy, productive. Leaves very large, attractive dark green; leaf stems rather long, medium to slender. Fruit stems medium to long, thickish, double, prostrate. Blooms and ripens in midseason, picks easily. Calyx medium to large, sometimes leafy, often discolorerd, variable in position. Seeds sunken. Fruit large to medium, retains size well in late pickings, wedge to roundish conic, surface furrowed, dull, unattractive light and dark scarlet. Flesh medium red, firm, mild, not high in flavor, fair to good. General appearance is coarse and unattractive.

Uncle Joe.—(Jas. Vicks Sons, Rochester, N. Y.) Perfect. Plants medium to numerous, vigorous, slightly injured by leaf blight, above medium in productiveness. Leaves large, rather dark green; leaf stems inclined to long and slender. Fruit stems long, rather thick, usually double, medium erect. Blooms and ripens in midseason, picks easily. Calyx medium to nearly large, sometimes leafy, somewhat discolored, often slightly raised. Seeds sunken. Fruit variable in size, ranging from large to medium, wedge shape or roundish conic varying to slightly elongated, surface of larger berries furrowed, dull, unattractive scarlet, coarse in appearance. Flesh light colored, medium juicy, mild, not high in flavor or quality. Fruit unattractive in color; flesh characters not desirable.

Uncle Sam.—(C. E. Whitten, Bridgman, Mich.) Perfect. Plants not numerous, of medium vigor, susceptible to attacks of leaf blight, produces fair crops. Leaves of medium size and color; leaf stems of average length, thick. Fruit stems short to medium, usually very thick, branched, semi-ereat. Blooms in midseason, ripens slightly after midseason, picks easily. Calyx medium to nearly large, somewhat leafy, attractive green, slightly depressed. Seeds numerous, slightly raised. Fruit large to medium, retains size fairly well as season advances, roundish conic, often with pointed apex, attractive bright scarlet. Flesh light colored, juicy, medium to firm, pleasant flavor, good in quality. A good shipper. Should be set closer than most varieties. Worthy of further testing.

Velvet.—(M. Crawford Co., Cuyahoga Falls, O.) Imperfect. Originated in 1891 by R. C. Cronk, Oregon, Wisconsin, and introduced about 1898 by F. H. Chapell, of that place. A seedling of Jessie crossed with Bubach No. 5. Plants very few in number,

lacking in vigor, healthy, productive. Leaves of medium size, light green; leaf stems short, slender. Fruit stems short, slender to medium, usually double, prostrate. Blooms and ripens in midseason, does not pick easily. Calyx small to medium, often discolored, slightly sunken. Seeds slightly depressed. Fruit nearly large to medium, roundish conic, blunt, dull dark scarlet. Flesh good color, moderately firm, juicy, not high flavor, fair quality. The berries are unattractive in appearance and the plants, as grown on the Station grounds, are too weak for commercial purposes.

Victor.— (M. Crawford Co., Cuyahoga Falls, O.) Perfect. Originated in 1893 by D. J. Miller, Millersburg, Ohio. Introduced in the fall of 1904 by the Crawford Company. Parentage unknown. Plants very few, moderately vigorous, considerable leaf blight, unproductive. Leaves of medium size, medium green; leaf stems short to medium, slender. Fruit stems short, thick, usually double, prostrate. Blooms early in midseason, ripens slightly past midseason, does not pick easily. Calyx of medium size, slightly raised. Seeds raised, numerous. Fruit nearly large to medium, drops rapidly in size as the season advances, roundish conic, dull dark scarlet. Flesh well colored, firm, juicy, agreeably acid, pleasant flavor, quality good. Fruit seedy in appearance and runs too small. Surpassed by other varieties.

Virginia.—(W. F. Allen, Salisbury, Md.) Imperfect. Originated in Accomac County, Virginia. Introduced by Mr. Allen. Said to bé a cross between Hoffman and Sharpless. Plants few in in number, of medium vigor, healthy, productive. Leaves inclined to large, rather dark green; leaf stems medium to long, thickish. Fruit stems of average length, thick, often single, prostrate. Blooms early in midseason, ripens slightly before midseason, picks easily. Calyx variable in size, reflexed, slightly sunken, often with pinkish tinge. Seeds deeply depressed. Fruit large to medium, dropping in size in later pickings, roundish conic to wedge, bluntly pointed and often with depression at apex, light and dark glossy scarlet, resembling Hunn. Flesh medium red, of average firmness, mild, not high in flavor. Surpassed by other varieties.

Williams.—(Carlton Fruit Farm, St. Catherines, Ontario, Canada.) Perfect. Plants few, of medium vigor, healthy, productive. Leaves mdium in size, dark green; leaf stems of fair length, somewhat slender. Fruit stems short to medium, variable in thickness,

often double, prostrate. Blooms and ripens late, picks medium easily. Calyx of medium size, not leafy, pale green, flat. Seeds raised. Fruit large to medium, dropping to small as the season advances, blunt, roundish conic, medium dark scarlet, slightly dull. Flesh dark red, firm, agreeably acid, pleasant flavor, good to very good. Fruit is more attractive early in season than later.

Worlds Wonder.—(Woodlawn Nurseries, Rochester, N. Y.) Imperfect. Originated by R. G. Parsons, Maryland. Plants moderately numerous, vigorous, susceptible to attacks of leaf blight, very productive. Leaves rather large, medium green; leaf stems long, quite thick. Fruit stems short, of average thickness, often single, prostrate. Blooms and ripens in midseason. Calyx rather large and leafy, sunken, slightly discolored. Seeds slightly depressed. Fruit averages above medium in size, blunt wedge, surface often irregularly furrowed, attractive scarlet. Flesh light color, firm, decidedly acid, pleasant flavor, good quality. Although the fruit is of good shape and excellent color, the berries run too small, especially toward the close of the season, pick only moderately easily and the acid flesh would be undesirable to many palates.

STRAWBERRY: CULTURAL DIRECTIONS.

Soil. Strawberries do well on a wide range of soils. It is usually possible to find some varieties which will thrive on almost any soil. The majority of growers prefer a light, warm, moist, sandy loam in preference to a cold, heavy clay. The ground shoul be well drained. A southern exposure on a rich, sandy loam favc early crops. A northern exposure on a heavier soil retards time of ripening.

Preparation of ground.—Weedy soils are expensive. T such conditions hoed crops should be grown for one or twc keeping the land free from weeds. Strawberries after c desirable. Sod soils should be avoided on account of d injury from work of the larvæ or grubs of the common M which lay their eggs in sod ground. The land may either in fall or spring. Heavy applications of stabl leguminous cover crops plowed under are beneficial their value as plant food and in absorbing and reta The ordinary preparation of land for corn or c

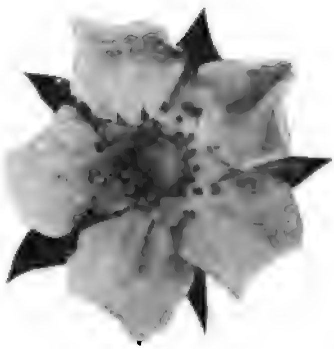
ficient. The soil should be made fine and mellow by thorough cultivation.

Fertilizers.—Available plant food should be present to meet the requirements of the plants. Congenial surroundings with plenty to eat and drink are plant essentials. Heavy applications of well-rotted stable manure and the plowing under of leguminous cover crops, as already indicated, are beneficial The weed seeds from the compost heap may cause trouble at times. Additional applications of plant food in the form of commercial fertilizers may be necessary. The kind and amount to use depend on the need of the soil. This may be entirely different in different localities or even on apparently similar soils in the same locality. The lack may be in nitrogen, potash or phosphoric acid. Applications of nitrogen in the form of nitrate of soda at the rate of from one hundred to two hundred pounds per acre, or dried blood at the rate of two hundred to four hundred pounds per acre, will stimulate growth. A lack of potash may be supplied by using wood ashes at the rate of two thousand pounds per acre, or by applications of muriate of potash at the rate of about five hundred pounds per acre. Phosphoric acid may be supplied in the form of acid phosphate using six hundred to seven hundred pounds per acre. Various other fertilizers might be named. If the soil is naturally well supplied with available potash or phosphoric acid nothing will be gained by additional applications. The aim shold be to find the actual needs of the particular soil. To this end it is desirable to make tests of different fertilizers leaving check rows for comparison. The fertilizers should be applied at the beginning of the growing season rather than in late fall. Applications the second spring may at times be beneficial.

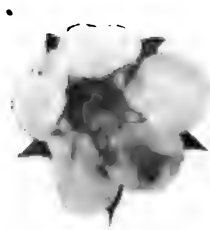
Selection of varieties.— Under different environments the same variety may be most profitable or become worthless. Its adaptation should be determined before an extensive use in the commercial plantation. This may be determined by a test of a few plants. The newer, most promising kinds should be tested and the local value determined before setting them in the main plantation, and only those varieties should be finally selected that make the best record locally and which meet the requirements of the market to be supplied.

Sex of plants.—Some attention must be given to the sex of the plants. Those varieties producing no pollen (imperfect) should alternate with the kinds producing pollen (perfect). If only those

varieties which are imperfect, *i. e.,* in which the blossoms contain no stamens in addition to the pistils, such as Cardinal, Columbia, Mark Hanna, Nettie, President, etc., be planted the result is usually a failure. Non-fertilization or incomplete fertilization is usually in-



PERFECT FLOWER.



IMPERFECT, OR PISTILLATE, FLOWER.

dicated by an abundance of nubbins, berries with hard greenish undeveloped apex. Heavy and continuous rains, unusually cool temperatures, or the absence of pollen-distributing insects at blossoming time, may, however, greatly decrease the setting of fruit of even those varieties most prolific in pollen bearing. These two classes should not be set in the same row, but from one to three rows of imperfect varieties may alternate with from one to three rows of perfect varieties. The kind of pollen does not appear to influence the character of the fruit. The berries of Senator Dunlap, for instance, always seem the same in size, color, shape and flavor, no matter whether the pollen be supplied from Chesapeake, Fairfield, Marshall, or Joe, which differ widely.

Selection of plants.— Plants in old beds are usually weakened in vitality and often more or less diseased. The best ones obtainable should be used. These as a rule may be found in well-cared-for yearling beds which have not yet fruited. Systematic selection intelligently followed for a series of years should result in an improved strain. If the so-called "pedigree" plants are superior to others it is because of this practice of intelligent, long-continued selection along desired lines of improvement.

Distance apart of plants.—It is a common occurrence to see plants crowded closely together in the row. A certain amount of moisture is essential to good size and yield. This cannot be secured under such crowded conditions. The distance apart of the rows

and of the plants in the row should vary somewhat, depending on the natural richness of the soil and on the ability of the variety to make runners. Those producing the largest number of plants, such as Mark Hanna, Ridgeway, Senator Dunlap, etc., may be set as far apart as four by two and one-half or three feet while the kinds making but few plants may be set three feet by eighteen inches, or even closer, an average distance for many varieties being three by two feet.

Time of setting the plants.— Periods of drought usually occur during the fall months and when plants are set under such conditions there may be considerable loss. It is difficult for the plants to make a satisfactory growth until the drought is broken, which period is often delayed until late in the season, leaving but a short time for growth before checked by cold weather. Fall set plants require winter protection and the usual cultural care during the ensuing summer followed by a second winter's protection before a full crop may be secured. In order to shorten the time from planting to fruitage and at the same time to secure better weather and soil conditions, it is the practice among the majority of growers to set early in the spring as soon as the soil and plants are in good condition for this work. The transplanting season, however, may extend through a long period beginning early in April and extending well through May. Plants obtained by rooting the first runners in small pots are sometimes set in early fall, but these are usually too expensive.

Summer treatment.— The work of cultivation should begin as soon as the plants are set and the soil should be thoroughly stirred about the plants as occasion requires, encouraging a steady normal growth throughout the season. Fruitage lessens plant growth. The blossom clusters should therefore be removed as soon as they appear in order to obtain stronger parent plants from which the runners are to develop. The first runners should be encouraged to root as soon as possible to give a long season for the young plants to develop in size and maturity. They should not become crowded. Some growers make a practice of removing some of these latter plants.

Winter treatment.— Repeated freezing and thawing weaken the plants and often greatly reduce the yield of fruit. To secure best results winter protection should be given. The most desirable covering is one which is free from weed seeds, spreads evenly, is not blown off by heavy winds and does not smother the plants. Vari-

ous materials, however, may be used for this purpose, such as straw or rough refuse, coarse stable manure, marsh hay, etc. A light coating is desired as it is only necessary to cover the plants out of sight, an inch or so being much better than three or four inches.

Spring treatment.—The mulching should be left over the plants as long as possible in spring to retain the frost, thus retarding the starting of the plants. As warm weather approaches, however, it may be necessary to shake up the covering to prevent the plants from smothering. Some of this material may be removed from over the plants and placed between the rows. No further treatment is generally necessary except to hand pull the larger weeds. Under some conditions, however, it may be necessary to remove the mulch and give thorough cultivation, replacing it before the berries ripen to conserve moisture and to keep the berries clean.

It is usually not considered a profitable undertaking to spray the foliage for fungus troubles, but where leaf blight is serious, it may be kept in check by applications of bordeaux mixture. The spraying should be made early in the season and should not be applied while the plants are in bloom, nor so late that the bordeaux shows on the fruit. Good air and soil drainage are aids in reducing the amount of injury.

Renewing old beds.—It is generally more satisfactory to set new beds each year than to continue the old ones. But if the plants are numerous, vigorous and healthy, and the ground not too weedy, they may be left for a second crop. Some successful growers harvest two and even three profitable crops of fruit before making a change. The berries ripen earlier on old beds than on one year beds. The ground which has become hard and compact from the tread of the pickers should be thoroughly broken up and the rows of plants cut back to narrow strips as soon as the fruiting season is over, giving thorough cultivation and fertilization as appears necessary.

Conclusion.—It must be kept in mind that the suggestions given above are not specific directions. The actual details vary widely in different places. These must be worked out by each grower under his own particular set of conditions. The different subjects have been treated in a general way giving briefly some indication of the methods pursued by a large number of successful growers.

INSPECTION WORK.

INSPECTION OF FEEDING STUFFS.*

(The analysis reported in these Bulletins cease to have value long before they would be reprinted in this Report; and are, therefore, omitted. Some comments on results of feeding stuffs inspection will be found in the Director's report (pages 14, 15 of this volume.—W. H. JORDAN, *Director.*)

REPORT OF ANALYSIS OF SAMPLES OF FERTILIZERS COLLECTED BY THE COMMISSIONER OF AGRICULTURE DURING 1908.†

(See note above.—W. H. JORDAN, *Director.*)

*Printed as Bulletin No. 303.
†Printed as Bulletin No. 304.

APPENDI

I. PERIODICALS RECEIVED BY TH

II. METEOROLOGICAL RECORDS.

Appendix.

PERIODICALS RECEIVED BY THE STATION.

Acclimitation	Complimentary
Agricultural Epitomist	Complimentary
Agricultural Experiments	Complimentary
Agricultural Gazette of New South Wales	Complimentary
Agricultural Journal and Mining Records (Natal)	Complimentary
Agricultural Journal of the Cape of Good Hope	Complimentary
Agricultural Ledger	Complimentary
Agricultural News	Complimentary
Allegan Gazette	Complimentary
American Agriculturist	Subscription
American Chemical Journal	Subscription
American Chemical Society, Journal	Subscription
American Cultivator	Complimentary
American Entomological Society, Transactions	Subscription
American Fancier	Subscription
American Fertilizer	Subscription
American Florist	Subscription
American Grange Bulletin	Complimentary
American Grocer	Complimentary
American Hay, Flour and Feed Journal	Complimentary
American Home Magazine	Complimentary
American Journal of Physiology	Subscription
American Miller	Complimentary
American Naturalist	Subscription
American Philosophical Society, Proceedings	Complimentary
American Poultry Advocate	Complimentary
American Poultry Journal	Complimentary
American Poultryman	Subscription
American Stock Keeper	Complimentary
Analyst	Subscription
Annales de l'Institut Pasteur	Subscription
Annales de la Societe Entomologique de Belgique	Complimentary
Annals and Magazine of Natural History	Subscription
Annals of Botany	Subscription
Archiv der gesammte Physiologie (Pflueger)	Subscription
Archiv fuer Hygiene	Subscription
Association Belge des Chimistes, Bulletin	Complimentary
Australian Garden and Field	Complimentary
Beet Sugar Gazette	Complimentary
Berichte der deutschen botanischen Gesellschaft	Subscription
Berichte der deutschen chemischen Gesellschaft	Subscription

Better Fruit	Complimentary
Biochemische Zeitschrift	Subscription
Biochemisches Centralblatt	Subscription
Biological Bulletin	Subscription
Biologisches Centralblatt	Subscription
Biophysikalisches Centralblatt	Subscription
Blooded Stock	Complimentary
Boletim de Agricultura	Complimentary
Boletim do Instituto Ageonomico	Complimentary
Boletin de la Sociedad Nacional de Agricultura	Complimentary
Boletin de Ministero de Frumento	Complimentary
Boston Society of Natural History, Proceedings	Subscription
Botanical Gazette	Subscription
Botanische Zeitung	Subscription
Biologisches Centralblatt	Subscription
Botaniste, Le	Subscription
Buffalo Society of Natural Sciences, Bulletin	Complimentary
Bulletin of the Department of Agriculture, Jamaica	Complimentary
Caledonia Era	Complimentary
California Cultivator	Complimentary
California Fruit Grower	Subscription
Canadian Entomologist	Subscription
Canadian Horticulturist	Complimentary
Cellule, La	Subscription
Centralblatt fuer Agrikultur-Chemie	Subscription
Centralblatt fuer Bakteriologie, etc	Subscription
Chemical Abstracts	Subscription
Chemical Society, Journal	Subscription
Chemisches Centralblatt	Subscription
Chicago Daily Drovers' Journal	Complimentary
Chicago Dairy Produce	Complimentary
Cincinnati Society of Natural History, Journal	Complimentary
Cold Storage and Ice Trades Review	Complimentary
Colman's Rural World	Complimentary
Colonial Dairy Produce Report	Complimentary
Columbus Horticultural Society, Journal	Complimentary
Commercial Poultry	Complimentary
Country Gentleman	Subscription
Country Life in America	Subscription
Country World	Complimentary
Criador Paulista	Complimentary
Cronica Agricola	Complimentary
Dairy and Creamery	Complimentary
Dairy and Produce Review	Complimentary
Down Town Topics	Complimentary
Elgin Dairy Report	Complimentary
Elisha Mitchell Scientific Society, Journal	Complimentary
Entomological News	Subscription
Entomological Society of Washington, Proceedings	Subscription

Entomologische Zeitschrift	Subscription
Entomologist	Subscription
Entomologists' Record	Subscription
Fanciers' Review	Complimentary
Fancy Fruit	Complimentary
Farm and Fireside	Complimentary
Farm and Live Stock Journal	Complimentary
Farm and Stock	Complimentary
Farm Journal	Complimentary
Farm Life	Complimentary
Farm News	Complimentary
Farm Poultry	Complimentary
Farm, Stock and Home	Complimentary
Farm Stock Success	Complimentary
Farmers' Advocate	Complimentary
Farmers' Call	Complimentary
Farmers' Guide	Complimentary
Farmers' Progress	Complimentary
Farmers' Sentinel	Complimentary
Farmers' Tribune	Complimentary
Farmers' Visitor	Complimentary
Farmers' Voice	Complimentary
Feather	Subscription
Feathered World	Subscription
Floral Life	Complimentary
Florists' Exchange	Subscription
Flour and Feed	Complimentary
Flour Trade News	Complimentary
Fruit Grower	Complimentary
Fruitman and Gardener	Complimentary
Garden	Subscription
Garden Magazine	Subscription
Gardeners' Chronicle	Subscription
Gardening	Subscription
Gartenwelt	Subscription
Gas and Oil Power	Complimentar
Gleanings in Bee Culture	Complimenta
Hartwick Seminary Monthly	Compliment
Hedwigia	Subscripti
Herd Register	Complim
Hoard's Dairyman	Complir
Holstein-Friesian Register	Compl
Holstein-Friesian World	Comp
Homestead	Com
Horn and Hoof	Co
Horticulture	S
Hygienische Rundschau	
Indiana Farmer	
Insect World (Japanese)	

Ithaca Chronicle	Complimentary
Jahresbericht der Agrikultur-Chemie	Subscription
Jahresbericht Garungs-Organismen	Subscription
Jahresbericht der Nahrungs-und Genussmittel	Subscription
Jahresbericht Pflanzenkrankheiten	Subscription
Jahresbericht der Tier-Chemie	Subscription
Jersey Bulletin	Complimentary
Journal of Agricultural Science	Subscription
Journal of Agriculture, Victoria	Complimentary
Journal of Biological Chemistry	Subscription
Journal de Botanique	Subscription
Journal of the Dept. of Agriculture of Western Australia	Complimentary
Journal of Experimental Medicine	Subscription
Journal of Experimental Zoology	Subscription
Journal fuer Landwirtschaft	Subscription
Journal of Mycology	Subscription
Journal of Physiology	Subscription
Just's Botanischer Jahresbericht	Subscription
Kimball's Dairy Farmer	Complimentary
Lanswirtschaft-Historische Blätter	Complimentary
Landwirtschaftlicher Jahrbucher	Subscription
Landwirtschaftlicher Jahrbuch der Schweiz	Subscription
Landwirtschaftlichen Versuchs-Stationen	Subscription
Live Stock and Dairy Journal	Complimentary
Live Stock Report	Complimentary
Long Island Democrat	Complimentary
Market Fruit-Growers' Journal	Complimentary
Marlboro Record	Complimentary
Memoirs of the Department of Agriculture in India	Complimentary
Metropolitan and Rural Home	Complimentary
Michigan Farmer	Complimentary
Milch Zeitung	Subscription
Milchwirtschaftliches Zentralblatt	Subscription
Minnesota and Dakota Farmer	Complimentary
Mirror and Farmer	Complimentary
Modern Farming	Complimentary
Monthly Weather Review	Complimentary
National Nurseryman	Complimentary
National Farmer and Stock Grower	Complimentary
National Grange	Complimentary
National Stockman and Farmer	Complimentary
Naturaliste Canadienne	Complimentary
Nebraska Farmer	Complimentary
New England Farmer	Complimentary
New York Academy of Science, Annals and Transactions	Subscription
New York Botanical Garden, Bulletin	Complimentary
New York Entomological Society, Journal	Subscription
New York Farmer	Complimentary
New York Fruit and Produce News	Complimentary
New York Tribune Farmer	Complimentary

New Zealand Dairyman	Complimentary
North American Horticulturist	Complimentary
Northwest Pacific Farmer	Complimentary
Nut Grower	Complimentary
Ohio Farmer	Complimentary
Ohio Naturalist	Subscription
Ohio Poultry Journal	Subscription
Pacific Coast Fanciers' Monthly	Subscription
Photo-Miniature	Subscription
Pacific Fruit World	Complimentary
Penn Yan Democrat	Complimentary
Popular Agriculturist	Complimentary
Poultry	Complimentary
Poultry Herald	Subscription
Poultry Husbandry	Complimentary
Poultry Industry	Complimentary
Poultry Keeper	Complimentary
Poultry Monthly	Complimentary
Power and the Engineer	Subscription
Practical Dairyman	Complimentary
Practical Farmer	Complimentary
Practical Fruit-Grower	Complimentary
Praktische Blätter fuer Pflanzenschutz	Subscription
Psyche	Subscription
Rabenhorst's Kryptogamen-Flora	Subscription
Reliable Poultry Journal	Subscription
Republic	Complimentary
Revue Generale de Botanique	Subscription
Revue Generale du Lait	Subscription
Revue Horticole	Subscription
Revue Mycologique	Subscription
Royal Agricultural Society, Journal	Subscription
Royal Horticultural Society, Journal	Subscription
Rural New Yorker	Subscription
Salt Lake Herald	Complimentary
Saint Louis Academy of Science, Transactions	Complimentary
Sanitary Inspector	Complimentary
Science	Subscription
Scientific American	Subscription
Scientific Roll, Bacteria	Subscription
Skaneateles Democrat	Complimentary
Society of Chemical Industry, Journal	Subscription
Societe Entomologique de France, Bulletin	Complimentary
Societe Entomologique Belgique, Annales	Complimentary
Societe Mycologique de France, Bulletin	Subscription
Southeast Missouri Farm, Fruit and Poultry	Complimentary
Southern Planter	Complimentary
Southern Tobacconist and Modern Farmer	Complimentary
Southern Farm Magazine	Complimentary
Southwestern Farmer and American Horticulturist	Complimentary

Southwestern Farmer and Breeder	Complimentary
Station, Farm and Dairy	Complimentary
Stazione Sperimentale Agrarie Italiane	Complimentary
Successful Farming	Complimentary
Suffolk Herald	Complimentary
Sugar Beet	Complimentary
Texas Stockman and Farmer	Complimentary
Torrey Botanical Club, Bulletins and Memoirs	Subscription
Transvaal Agricultural Journal	Complimentary
Up-to-Date Farming and Gardening	Complimentary
Utica Semi-Weekly Press	Complimentary
Wallace's Farmer	Complimentary
West Indian Bulletin	Complimentary
West Virginia Farm Review	Complimentary
Western Fruit-Grower	Complimentary
Western Plowman	Complimentary
Zeitschrift fuer Analytische Chemie	Subscription
Zeitschrift fuer Biologie	Subscription
Zeitschrift fuer Entomologie	Complimentary
Zeitschrift fuer Fleisch und Milch Hygiene	Subscription
Zeitschrift fuer Hygiene und Infektions Krankheiten	Subscription
Zeitschrift fuer Pflanzenkrankheiten	Subscription
Zeitschrift fuer Physiologische Chemie	Subscription
Zeitschrift fuer Untersuchung der Nahrungs und Genusmittel	Subscription
Zoological Record	Subscription
Zoologischer Anzeiger	Subscription

METEOROLOGICAL RECORDS FOR 1908.

READING OF THE STANDARD AIR THERMOMETER.

1908.	January.			February.			March.			April.			May.			June.		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	31.	37.	34.	25.	33.5	29.	15.5	20.	25.	26.	37.	44.	35.	43.	44.	51.	59.	67.
2	26.5	28.	26.5	11.	14.	12.	36.	36.	33.	35.	36.5	31.	40.	52.	38.	59.	66.	68.
3	24.	32.5	27.5	14.	21.	13.	24.	28.	24.5	24.	26.	27.	38.	49.	47.	59.	72.	78.
4	31.	33.5	40.	—4.	—2.	0.	21.	27.	25.	25.	28.	33.	45.	52.	54.	66.	78.	77.
5	15.	13.	16.5	—2.	5.	12.	30.	32.	32.5	28.	46.5	45.	47.	57.	57.	63.	76.	76.
6	13.	30.	35.	30.	23.	26.	28.	31.	35.	40.	57.	63.	49.	47.5	45.	61.	74.	79.
7	26.	33.	30.	13.	14.	16.	37.	33.	33.	44.	50.	50.	45.	45.5	49.	65.5	79.5	87.
8	30.	35.	32.	7.	8.	4.	34.	37.	35.	36.	53.	51.	47.	52.	55.	72.	84.	91.
9	22.	21.	15.	—3.	16.	14.	25.	24.	23.	30.	36.	43.5	44.5	42.	48.	73.	84.	75.
10	12.	23.	21.5	10.	28.	33.	17.	25.	25.	36.5	58.	56.	40.5	45.	54.5	64.	68.	68.
11	22.	32.	33.	13.	40.	39.	41.	49.	49.	48.	40.	37.	59.	73.	75.	60.	65.5	67.
12	34.	35.5	35.	19.	37.	38.	36.	47.	44.	32.	42.	40.	58.	78.	77.	57.	67.	76.
13	30.	29.	27.5	37.	41.	42.	40.	53.	48.	46.	40.	44.	52.	57.5	57.	64.	80.	85.
14	18.5	21.5	20.	37.	39.	42.	30.	41.	46.	35.	50.	59.	50.	51.	55.	68.	83.	68.
15	27.	32.	35.	45.	48.	39.	45.	44.	39.	48.	50.	44.	51.	51.	49.	54.	55.	58.
16	38.	24.	17.5	24.5	27.	24.	32.	27.	27.	27.5	31.5	36.	52.	65.	75.	55.	62.	66.
17	20.	25.	29.5	17.	21.	17.	21.	25.	33.	28.	44.	55.5	58.5	67.	68.	60.	67.5	71.
18	28.5	31.	32.5	11.5	20.	24.	28.	32.	37.	43.	52.	49.	59.	71.	75.	63.5	77.	79.
19	30.	22.	20.	25.	28.	29.	31.	28.	27.	45.	43.5	47.	60.	70.	75.	69.	88.	91.
20	29.	40.	40.	18.	19.	19.	20.	27.	29.5	33.	39.	41.	61.5	65.5	73.5	74.	83.	82.
21	32.	41.	40.	21.	31.	33.	21.	36.	41.	31.	41.	47.	63.	70.5	73.	74.5	84.	86.5
22	39.	36.5	32.5	17.	20.	17.	35.	47.	52.	44.	61.	71.	66.	71.	72.	74.5	85.	85.
23	29.	31.	29.	14.	21.5	21.	41.	46.5	48.	62.	70.	63.	67.	80.	78.	70.	84.	75.5
24	15.	15.	14.	16.	23.5	23.5	41.	48.	35.5	49.	66.5	74.	62.	72.5	72.5	70.	86.	83.
25	21.5	24.	29.	22.	32.	33.	20.	28.	31.5	57.	63.	67.	62.5	78.	84.	67.5	74.	78.
26	29.	30.	34.	34.	35.	34.	40.5	66.	64.5	62.	75.	68.	72.	86.	76.	63.	76.	78.
27	19.	18.	16.5	25.	24.5	24.	35.	36.	36.	58.	76.	54.	70.	78.5	77.5	66.	78.5	81.
28	14.	28.	29.	11.	17.5	17.5	59.	72.	64.	46.5	55.	56.	67.	83.5	86.5	71.	79.	84.
29	16.	14.5	8.	12.	18.	20.	31.	33.	33.5	45.	50.	45.	75.	87.	69.	71.	84.	86.
30	5.	3.	3.	......	......	......	32.	44.	48.	40.	37.	35.	66.	76.5	66.	63.	73.	75.5
31	3.5	20.	16.	......	......	......	40.	43.	45.	......	......	......	67.	74.	71.	......	......	......
Monthly averages	23.	27.1	26.4	17.9	24.4	24.	31.8	37.6	37.7	40.1	48.5	49.1	55.8	64.2	64.4	64.9	75.7	77.4

READING OF THE STANDARD AIR THERMOMETER — (*Concluded*).

1908.	July.			August.			September.			October.			November.			December.		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	67.5	82.	85.5	61.	75.	77.	68.	86.	85.	54.	57.	54.5	31.5	39.	36.	49.	47.	35.
2	71.	80.	77.	66.5	79.	79.	62.	72.5	56.	43.	47.	49.5	31.	41.	42.	19.	23.5	19.5
3	68.	81.	83.	63.	79.	83.	54.	64.	68.	40.	56.5	62.5	43.	56.5	53.	22.	29.	28.
4	71.	84.	74.	74.	91.	93.	53.	76.5	80.	44.	67.	58.	34.	27.	25.	31.	35.5	33.5
5	79.	83.	85.	70.	75.	81.	62.5	79.	83.	46.	60.	59.	26.	34.	35.	22.5	23.	17.
6	75.	89.	93.	68.	82.	82.	65.	81.	68.	46.	67.	68.	32.	36.	39.	15.	19.	28.
7	78.	89.	89.	64.	71.	71.	55.	68.	71.	52.	65.	67.5	38.	42.	43.	36.	37.5	31.5
8	58.	66.	74.	64.	75.	77.	55.	69.	70.5	50.	64.	57.	39.	42.	44.	22.	26.5	26.5
9	66.	77.	83.	65.	78.	77.	57.	83.	86.	51.	50.5	49.	41.	59.	47.	25.	26.	22.
10	67.	83.	85.	66.	73.	70.	60.	86.5	86.	37.	57.	63.	33.	38.	39.	5.5	25.	18.
11	71.	90.	92.	65.	76.	76.	61.5	82.5	79.	56.	57.	52.	41.	44.	38.	27.	34.5	36.
12	78.5	81.	84.	67.	77.5	80.	61.5	76.	77.	35.5	47.	45.	28.	34.	34.	32.	30.	28.
13	69.	82.5	82.5	75.	79.	73.	59.	79.	78.	36.	58.	36.	33.	36.	36.	28.	34.	33.
14	68.5	64.	76.	68.	81.	81.5	57.	72.	66.	41.	66.	68.	28.	39.	35.	27.	39.	38.
15	63.	69.	73.5	67.	76.	74.	53.	72.	71.	56.5	75.	73.	26.	33.5	31.	38.	49.	42.
16	63.	72.	74.	61.	76.	75.	45.	73.	70.	53.	79.	72.	27.	37.	31.	34.	34.5	32.
17	63.	62.	66.	70.	85.	81.	53.5	72.	72.	50.5	70.5	66.	28.	54.	32.	26.	26.	24.
18	74.	70.5	83.	63.	72.	74.	52.	79.	79.	50.5	79.	61.	34.	41.	38.	33.	38.	24.
19	67.	75.	76.	64.	70.	70.	61.	60.	63.5	58.	52.	49.	37.	48.	50.	29.	39.	33.
20	67.	76.	78.	55.5	65.	70.	49.	70.	76.	39.	52.5	49.	38.	40.	35.5	27.	33.	28.
21	66.	67.5	68.	60.	75.	77.	59.	78.5	81.	30.	52.5	53.	27.5	46.	43.	36.	36.5	30.
22	67.	80.	83.5	68.	77.	80.	61.	77.	73.	39.	60.	58.	34.	48.	47.	18.	23.5	18.
23	69.	79.	81.	57.	65.	71.	58.	83.	85.	48.5	64.	61.	42.	53.	51.	6.5	25.	19.
24	68.	80.	78.	60.	70.	69.	66.	80.	82.	59.5	65.	63.	47.	59.	53.	29.5	39.	37.
25	67.	75.	79.	57.	73.	69.	61.	82.	84.	61.	62.5	64.5	59.	64.	58.	36.	38.	37.
26	65.	79.	83.	54.	73.	70.	61.	79.	83.5	59.	62.	59.5	57.	60.	58.	32.	30.5	30.
27	71.	85.	88.	55.	71.	73.	67.	76.	72.	59.5	64.	52.	43.	45.	38.	27.	37.	38.
28	69.	87.	88.	57.	70.5	72.	67.5	73.	74.	48.	51.	51.5	34.	45.5	44.	29.	34.	31.
29	75.	90.	90.	60.	76.	77.	46.	55.	51.	48.5	53.	48.	33.	49.5	43.	34.	39.	31.
30	75.	90.	93.	62.	88.5	86.	43.	59.	62.	42.	44.	35.	42.	50.	58.	33.	37.5	38.
31	76.	89.	82.	62.	86.	85.	......	......	......	35.	38.	36.	......	......	......	28.	29.	27.
Monthly averages	69.4	79.3	81.6	63.5	76.1	76.6	57.8	74.8	74.4	47.4	59.5	56.8	36.2	44.7	41.9	27.	32.8	29.5

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1908.

DATE.	January. 5 P. M. Max.	January. 5 P. M. Min.	February. 5 P. M. Max.	February. 5 P. M. Min.	March. 5 P. M. Max.	March. 5 P. M. Min.	April. 5 P. M. Max.	April. 5 P. M. Min.	May. 5 P. M. Max.	May. 5 P. M. Min.	June. 5 P. M. Max.	June. 5 P. M. Min.
1	38.5	29.	37.	11.	25.	8.	47.	24.	45.	31.	71.	49.5
2	36.	25.	32.	—14.	40.	24.	48.	24.	56.	33.	69.	54.5
3	35.	23.	24.	9.	32.	22.	32.	22.	52.	34.	78.	45.
4	40.	21.	13.	—7.	31.	20.	33.5	18.	56.	31.	81.5	52.
5	40.	11.	12.	—14.	35.5	15.	50.	21.	60.	31.	79.	48.
6	42.5	10.	30.	1.	35.	25.	63.5	35.5	57.	41.	80.	54.
7	35.	25.	28.5	10.	45.	27.	63.	41.	49.	42.	87.	57.
8	38.	28.	16.	46.	37.	31.	60.	34.	57.	45.	91.5	60.
9	32.	15.	19.	—5.	37.	21.	51.	27.	56.	40.	91.	65.
10	25.	12.	36.	—3.	26.	15.	63.5	30.	54.5	36.	75.	54.
11	36.5	20.	44.	12.	51.	21.	56.	32.	77.	45.	71.	54.
12	38.	31.	41.	14.	49.	33.	44.	29.	80.	46.	76.	43.
13	36.	27.	45.	34.	54.	30.	48.	32.	77.	50.	85.5	50.
14	27.5	16.	42.	35.	48.	27.5	64.	25.	57.	47.	88.	64.
15	37.	14.	53.	38.	52.	38.	58.	43.	55.	48.	69.	51.
16	39.5	17.	41.	22.	39.	25.	44.	24.	78.	44.5	66.	50.
17	30.5	10.5	24.	15.	33.	17.	56.	23.	75.	55.	73.	46.
18	35.	26.	29.	11.	37.	24.	55.5	22.5	76.	46.	80.5	50.
19	32.5	19.	30.	20.	37.	26.	49.	40.	77.	55.	92.	62.
20	43.	19.	29.	16.	32.	18.	47.	31.	75.	56.	91.	63.5
21	44.	31.	36.5	8.5	42.	16.	49.	20.	75.5	60.	87.5	68.5
22	45.	28.	33.	15.	54.	31.	74.	40.	75.	60.	89.5	64.
23	33.	26.	27.5	7.	52.	38.	73.	54.	82.	62.5	87.5	65.
24	29.	12.	30.	12.	48.	23.	75.	38.	78.	56.	88.5	67.
25	29.	0.	33.	13.	35.5	19.	74.	53.	85.	47.5	83.	58.
26	34.	25.	37.	29.	67.5	29.	76.	47.	87.	65.	80.	53.5
27	38.	11.	34.	21.	64.5	33.	78.	47.	80.5	62.5	82.	54.
28	30.	10.	24.	8.	73.	28.	59.	44.	87.5	55.	85.5	56.
29	33.	7.	22.	11.	64.	29.	56.	42.	90.	66.	88.	63.
30	8.	—6.	......	......	48.5	29.	46.	34.	80.	59.5	87.5	57.
31	21.	—9.	......	......	48.	32.	......	......	75.	58.	......	......
Monthly averages	34.2	17.6	31.1	11.5	44.3	25.	56.4	33.2	69.8	48.7	81.8	55.9

READING OF MAXIMUM AND MINIMUM THERMOMETER FOR 1908 — (*Concluded*).

DATE.	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.
1	88.	55.5	82.	57.	89.	60.	62.	52.	41.	29.	64.	34.
2	86.5	61.	80.	60.	85.	55.	55.	40.	44.	29.	32.	15.
3	87.	60.	85.	52.	71.	50.	64.5	34.	60.	35.	32.	16.
4	85.	67.	95.	68.	82.	42.	68.	37.	34.	25.	36.	22.
5	87.	67.	93.	67.	86.	49.	65.	37.	39.	18.	35.	16.
6	94.	63.	83.5	61.	85.	60.	73.	37.	40.	30.	28.	8.
7	93.5	71.	82.	60.5	73.	51.	72.	50.	44.	30.	40.	26.
8	89.	53.	78.	60.	76.	48.	63.	48.	47.	38.	33.	16.
9	83.	52.	81.	56.	88.	49.	57.	39.	59.	35.	29.	22.
10	87.	55.	79.	59.	92.	57.	64.	32.	48.	29.	29.	4.
11	94.	59.	81.	62.	87.	60.	63.	51.5	47.	36.	36.	13.
12	92.	69.	80.	57.	83.	58.5	53.	33.	39.	26.	32.	26.
13	86.	63.	80.	67.	79.	53.	62.5	31.	40.	36.	36.	18.
14	84.5	62.	85.	61.	78.	52.5	77.	38.	40.	33.	42.	29.
15	76.	57.	82.	61.5	74.	41.	82.	55.	35.	23.	50.	35.
16	77.	54.	83.	50.	74.	40.	82.5	48.	41.	21.	42.	31.
17	74.	55.	85.	67.	77.	48.5	73.	49.	37.	26.	33.	23.
18	83.	64.	81.	59.	83.	47.5	83.	48.	41.	30.	40.	22.
19	83.	62.	74.	51.	79.	57.	59.	48.	52.	33.	47.	23.
20	79.5	57.	71.	49.	79.	45.	56.	32.	50.	34.	39.	26.
21	78.	64.	80.	47.	85.	56.	57.	27.	52.	25.	38.	23.
22	84.	64.	83.	63.	81.	60.	65.	35.	51.	32.	30.	15.
23	83.	63.	80.	50.5	89.	56.	60.	39.5	57.	40.	30.	3.
24	85.	60.	75.	49.	86.5	62.	65.	46.	60.	40.	39.	13.
25	81.5	65.	74.	46.	89.	58.	67.	49.	66.	49.	41.	29.
26	85.	59.	75.	50.	88.	60.	65.	57.	68.	53.	37.	28.
27	88.	55.5	76.5	48.	84.	62.	66.	46.	48.	31.	43.	24.
28	91.	61.	74.	50.	78.5	61.	52.	44.	49.	32.	39.	18.
29	91.	62.	79.	49.	74.	43.	56.	46.	51.	31.	40.	29.
30	94.	65.	88.5	57.	65.5	37.	49.	34.	61.	31.	39.	22.
31	93.	66.5	89.	55.	......	......	48.	31.5	......	......	32.	21.
Monthly averages	85.9	61.	81.1	56.4	81.3	52.6	64.	41.8	48.	32.	37.5	21.

AVERAGE MONTHLY AND YEARLY TEMPERATURE SINCE 1882.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Yearly Averages
1883	17.4	22.3	23.6	43.3	52.0	66.6	67.4	65.6	56.3	46.6	39.1	27.5	44.0
1884	17.6	28.3	29.5	40.7	54.3	67.1	66.5	69.9	65.2	50.5	36.5	27.2	46.1
1885	20.6	11.4	18.8	41.2	54.3	63.6	69.7	65.0	58.3	49.2	39.3	27.8	43.3
1886	19.6	22.9	30.2	48.1	55.7	64.0	68.0	67.5	61.8	49.6	36.8	22.2	45.5
1887	20.2	23.2	26.3	41.1	62.5	65.7	75.6	66.5	57.7	47.0	37.6	27.6	45.9
1888	16.4	22.8	24.6	40.8	54.3	66.5	66.8	68.0	62.2	43.9	39.4	29.3	44.6
1889	29.1	18.1	33.9	45.1	58.4	65.3	70.2	66.0	60.5	44.0	40.3	35.2	47.2
1890	31.2	30.9	28.8	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4	46.7
1891	25.9	28.3	30.8	45.3	52.0	66.4	66.4	68.5	66.2	48.3	38.4	35.5	47.7
1892	21.4	25.9	26.5	43.5	52.8	68.6	70.2	69.4	61.2	50.0	35.9	25.2	45.9
1893	15.5	20.6	29.5	41.1	54.1	68.2	69.8	68.8	58.0	52.0	38.2	27.5	45.3
1894	29.7	20.6	38.9	44.1	55.5	67.8	74.2	66.8	64.9	52.7	36.0	31.5	48.6
1895	21.8	16.9	26.9	44.4	59.0	......	......	71.2	61.7	45.4	39.6	31.4	......
1896	22.4	24.1	24.4	49.3	62.0	65.9	71.4	70.0	60.2	56.5	42.9	27.1	48.0
1897	23.2	26.1	33.8	45.0	55.4	62.3	73.6	67.6	62.3	52.6	39.7	29.2	47.6
1898	26.2	26.8	......	43.2	57.0	67.7	74.2	71.0	65.9	52.1	37.9	27.9	......
1899	22.1	20.4	30.4	46.6	57.6	69.5	71.2	71.6	60.6	53.5	38.9	30.0	47.7
1900	26.0	22.6	23.6	43.5	56.7	68.4	72.6	74.1	66.1	57.9	41.1	28.7	48.4
1901	26.1	18.5	32.2	46.5	56.9	68.9	76.6	71.0	64.0	51.4	34.3	27.7	47.9
1902	23.2	22.2	39.5	46.6	56.1	63.2	71.2	67.6	63.6	43.1	46.3	25.7	47.4
1903	25.7	28.1	42.4	45.9	60.4	63.2	70.8	65.5	64.4	52.5	36.2	23.3	48.2
1904	18.9	23.1	30.9	41.4	60.3	67.8	70.0	68.2	61.9	48.4	36.9	22.5	45.9
1905	19.8	18.9	33.1	44.8	57.5	66.4	71.8	68.7	63.7	52.4	37.6	32.0	47.2
1906	32.5	26.1	27.6	46.4	57.5	68.2	71.4	72.8	67.3	51.2	37.9	26.1	48.8
1907	24.9	19.5	38.1	40.2	51.3	64.0	71.2	68.4	64.4	47.9	38.7	31.8	46.7
1908	25.9	21.3	34.6	44.8	59.2	68.8	73.4	68.8	67.	52.9	40.0	29.2	48.8
Monthly averages	23.2	22.7	30.4	44.1	56.3	66.4	70.9	68.7	62.5	50.	38.6	28.1	46.8

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1908 INCLUSIVE.

(Highest and Lowest Record for Each Month in Heavy Type.)

	JANUARY.				FEBRUARY.				MARCH.				APRIL.			
	Max.		Min.		Max.		Min.		Max.		Min.		Max.		Min.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	18.	44.	11.	—9.	17.	48.	24.	—2.	19.	61.	9.	2.	16.	75.	1.	19.
1884	14.	42.	26.	—13.	7.	55.	29.	—3.	30.	54.	1.	—4.	28.	74.	1.	23.
1885	1.	61.	29.	—6.	10.	38.	11.	—11.5	28.	48.	13.	—11.	24.	84.5	10.	20.5
1886	5.	52.5	13.	—18.7	9.	50.	27.	—11.	16.	58.	2.	—2.5	24.	80.5	4.	22.
1887	24.	50.7	19.	—8.	9.	54.2	27.	—4.	3.	51.7	1 & 5	8.7	11.	75.7	1.	17.2
1888	2.	43.2	23.	—6.	21.	49.	10.	—7.	28.	57.	13.	0.	29.	82.5	8.	19.
1889	18.	55.	20.	5.	23.	42.	4 & 24	—7.	28.	61.8	30.	18.5	20.	84.	1.	26.
1890	6.	67.	29.	9.	5.	64.5	11 & 21	9.5	13.	62.	8.	2.	13.	78.8	1 & 19	23.
1891	3.	46.	17.	4.	26.	56.8	15.	2.5	12.	57.	2.	4.5	28.	81.4	7.	21.
1892	3.	48.	10.	—5.	15.	44.	6.	2.8	27.	52.2	4.	6.	6.	78.	17.	25.5
1893	29.	46.	11.	—6.	15.	47.4	5.	—1.	24.	54.	5.	9.	13.	75.3	26.	25.
1894	5.	59.	13.	11.	20.	47.6	27.	—8.5	18.	73.	26.	15.	21.	71.3	2.	20.
1895a	7.	45.	19.	4.	25.	46.	8.	—14.	25.	52.	5 & 16	12.	30.	80.	8.	28.
1896	30.	44.	6.	—16.5	29.	49.	17.	—21.	31.	56.5	24.	—2.	17.	87.	4 & 5	19.
1897	5.	58.	20.	—3.5	18.	49.5	1 & 27	5.5	21.	64.	1.	—1.	26.	82.	20.	19.
1898	13.	57.	30 & 31	—4.	12.	56.5	2 & 3	—2.	11.	o65.	2.	17.5	14 & 18	69.	5.	18.
1899	5.	59.	12.	—4.	21.	52.5	11.	—8.	13.	63.	21.	13.	30.	82.	3.	23.
1900	23.	56.	1.	2.	14.	57.	27.	0.	10.	46.	12.	—3.	30.	g73.5	9.	g22.
1901	16.	48.	20.	—2.	16.	36.	24.	—2.5	24.	67.	6.	—1.	28.	78.	12.	28.
1902	3.	44.	28.	2.	28.	52.	6.	—3.	12.	66.5	19.	14.	22.	87.	5.	25.
1903	3.	48.	9.	—2.	28.	62.5	18.	—4.	19.	78.5	1 & 2	19.	30.	86.	5.	21.
1904	23.	48.	19.	—14.	7.	58.	16.	18.	26.	58.	4.	8.	24.	67.5	14.	16.
1905	1.	49.	26.	—2.	20.	45.	5 & 14	—6.	29.	82.	5.	1.	27 & 28	75.	16.	23.
1906	21.	71.	9.	4.	24.	64.	6 & 7	—7.	27.	51.	25.	2.	19.	74.	2.	25.
1907	6.	53.	24.	—18.	2.	47.	12.	—4.	29.	83.	7.	—1.	29.	73.	2.	19.
1908	22.	45.	31.	—9.	15.	53.	2 & 5	—14.	28.	73.	1.	8.	27.	78.	4.	18.

o Maximum for first eleven days only. Record incomplete.
g Thermometers broken. Record not taken from April 19th to 24th inclusive.
a Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1908 INCLUSIVE—(*Continued*).

(Highest and Lowest Record for Each Month in Heavy Type.)

	May.				June.				July.				August.			
	Max.		Min.		Max.		Min.		Max.		Min.		Max.		Min.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	11.	87.	1 & 14	31.	7.	86.5	2.	42.	5.	89.	1.	46.	23.	92.	15.	46.
1884	24.	88.	30.	32.	25.	90.5	15.	41.	2.	87.5	15.	50.5	20.	95.	25.	44.
1885	18.	81.7	3.	27.5	14.	86.5	23.	41.5	18.	90.5	12.	46.5	1.	89.	28.	45.
1886	23.	79.5	17 & 18	37.2	14.	86.2	1.	42.2	7.	95.	1.	45.2	30.	91.5	6.	47.7
1887	23.	88.2	14.	37.5	17.	89.2	15.	47.7	3.	95.5	11.	58.7	3.	88.5	8.	46.
1888	13.	79.8	3.	29.	23.	94.1	4.	40.	5.	89.8	16.	47.	9.	92.6	23.	48.3
1889	18.	91.8	29.	32.	22.	85.	5.	46.	11.	90.7	6.	50.5	31.	86.7	16 & 17	50.3
1890	4.	80.7	2.	30.	30.	85.6	8.	44.8	9.	94.5	24.	46.5	4.	96.2	24.	46.0
1891	11.	85.5	4.	29.5	16.	95.	6.	40.	14.	92.	31.	46.	12.	92.	29.	46.5
1892	31.	78.	9.	34.2	14.	92.	11.	45.8	29.	96.3	2.	46.4	10.	95.5	28.	49.
1893	25.	88.	9.	35.	21.	94.	1.	44.	26.	95.5	24.	48.4	11.	94.5	13.	49.
1894	2.	85.4	14.	32.6	23.	91.6	6.	39.	21.	97.	10.	49.6	25.	93.	27.	45.3
1895o	31.	92.	13 & 21	36.	3.	96.	7.	54.	8.	94.	11.	52.	11.	88.	22.	44.
1896	11.	87.5	7 & 20	40.	21.	89.	3.	41.	3.	94.	18.	49.	6 & 7	96.	29.	44.
1897	24.	80.	8.	32.5	24 & 25	87.5	2.	42.	11.	97.	15.	57.	15.	87.5	21.	46.
1898	29.	79.	6.	34.	9.	90.	16.	40.	4.	96.5	12.	40.	24.	90.5	28.	47.
1899	2.	87.5	15.	32.5	6 & 24	93.	11.	41.5	4.	97.5	1.	50.	20.	97.5	15.	44.5
1900	15 & 16	88.5	7.	27.	25.	93.	10.	45.	17.	96.	1.	50.	11.	97.	2.	51.
1901	23.	78.	16.	36.	27, 28 & 29	95.5	2.	42.	1.	97.5	20.	54.5	22.	90.	5.	52.
1902	22.	90.	11.	26.	3.	85.	6.	38.	14 & 27	90.	1.	53.	31.	90.	13.	47.
1903	19.	89.	2.	24.	30.	86.5	1.	39.	9.	94.	15.	50.	18.	85.5	8 & 14	45.
1904	25.	88.	12.	31.5	5–24 & 25.	89.	12 & 17	45.	19.	93.	3.	49.	25.	89.5	19.	45.
1905	3.	82.	2.	29.5	19.	90.	1.	40.	18.	92.	22.	48.5	10.	93.	27.	41.
1906	24.	88.5	11 & 21	30.	8.	92.	12.	37.	20–22 & 23	89.	25.	50.	5.	93.	16.	47.
1907	14.	85.	2–11 & 12	28.	18.	94.	3.	41.	18.	90.	4.	46.	12.	96.5	19.	41.5
1908	29.	90.	1–4 & 5	31.	19.	92.	12.	43.	6–11 & 30	94.	9.	52.	4.	95.	25.	46.

o Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1908 INCLUSIVE — (*Concluded*).

(Highest and Lowest Record for Each Month in Heavy Type.)

	September.				October.				November.				December.			
	Max.		Min.		Max.		Min.		Max.		Min.		Max.		Min.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	17.	80.	11.	37.	11.	78.	17 & 18	25.	22.	70.	17.	13.	9 & 14	56.	23.	—7.5
1884	5.	94.	14.	36.	5.	84.2	27.	23.	11.	62.	25.	15.	31.	55.5	20.	—15.5
1885	27.	83.7	24.	40.	1.	79.	31.	25.	8 & 13	68.	28.	18.	24.	53.	9.	4.
1886	11.	89.5	22.	40.	10.	76.7	17.	27.5	3.	68.2	28.	17.	11 & 25	46.	6.	—6.
1887	22.	81.7	27.	37.2	9.	78.5	31.	21.2	28.	68.	30.	15.	12.	54.7	2.	—3.
1888	1 & 10	83.	7.	40.	6.	62.7	22.	29.	1 & 3	73.	23.	8.	27.	53.	22.	4.
1889	4.	84.	22 & 23 & 29	40.	2.	68.7	24.	21.2	4.	61.7	17.	17.8	25.	60.5	4 & 5	8.
1890	8.	83.6	25.	35.5	5.	69.8	31.	32.	8.	65.4	28.	17.	1.	46.2	20.	3.
1891	26.	92.8	30.	43.	4.	89.4	12 & 25	27.	1.	68.	29.	12.	5.	57.7	18.	7.
1892	26.	88.	20.	39.	1.	82.	2.	33.1	19.	60.	24.	18.	9.	49.2	27.	—3.7
1893	5.	80.	26.	37.4	13.	76.	31.	25.	3.	62.2	27.	19.	26.	62.	14.	1.5
1894	4.	90.	26.	33.	1.	76.5	15.	33.	3.	65.	29.	12.	17.	59.	29.	—0.2
1895	4.	94.	15 & 30	42.	2.	72.	30.	28.	7.	68.	21.	19.	20 & 21	62.	13.	—2.
1896	12.	95.	23.	36.	30.	77.5	10 & 19	29.	19.	70.	21.	19.5	14.	58.	28.	2.
1897	11.	98.	21.	37.5	16.	88.	10 & 18	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1898	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

YEARLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1908 INCLUSIVE.

(Highest and Lowest Record for Each Month in Heavy Type.)

	Maximum for each year.		Minimum for each year.	
	Date.	Temp.	Date.	Temp.
1883	Aug. 23	92.	Jan. 11	— 9.
1884	Aug. 20	95.	Dec. 20	—15.5
1885	July 18	90.5	Feb. 11	—11.5
1886	July 7	95.	Jan. 13	—18.7
1887	July 3	95.5	Jan. 19	— 8.
1888	June 23	94.1	Feb. 10	— 7.
1889	May 18	91.8	Feb. 4 and 24	— 7.
1890	Aug. 4	96.2	Mar. 8	2
1891	June 16	95.	Feb. 15	2.5
1892	July 29	96.3	Jan. 10	— 5.
1893	July 26	95.5	Jan. 11	— 6.
1894	July 21	97.	Feb. 27	— 8.5
1895‡	June 3	96.	Feb 8	—14.
1896	Aug. 6 and 7	96.	Feb. 17	—21.
1897	Sept. 11	98.	Jan. 20	— 3.5
1898	July 4	96.5	Jan. 30 and 31	— 4.
1899	July 4 and Aug. 20	97.5	Feb. 11	— 8.
1900	Aug. 1	97.	Feb. 27	0.
1901	July 1	97.5	Feb. 24	2.5
1902	May 24, July 14 and 27, August 31 and Sept. 1	90.	Dec. 9	— 5.
1903	July 9	94.	Feb. 18 and Dec. 19.	— 4.
1904	July 19	93.	Feb. 16	—18.
1905	Aug. 10	93.	Feb. 5 and 14	— 6.
1906	Aug. 5	93.	Feb. 6 and 7	— 7.
1907	Aug. 12	96.5	Jan. 24	—18.
1908	Aug. 4	95.	Jan. 2 and 5	—14.

‡ Data from record kept by Mr. Edgar Parker; Station record not available.

Rainfall by Months Since 1882.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1882	......	......	......	......	......	3.69	2.42	2.37	1.25	0.62	1.22	0.55	......
1883	0.48	1.44	0.88	1.58	4.45	4.12	2.98	3.47	2.12	2.10	1.54	0.73	25.89
1884	1.83	2.01	2.54	0.83	2.49	2.01	2.33	1.44	3.17	1.67	1.01	0.97	22.30
1885	1.07	0.61	0.12	1.26	1.58	2.49	4.64	5.02	2.11	2.88	1.36	0.76	23.90
1886	1.13	0.95	1.13	4.13	1.92	2.92	4.41	2.86	2.31	1.79	3.48	1.24	27.87
1887	0.18	2.97	0.48	1.37	0.46	2.01	6.37	3.03	0.75	1.74	1.58	1.35	22.29
1888	0.78	1.04	1.43	3.09	2.79	3.88	0.99 +	4.02	2.73	3.47	2.02	1.24	27.48
1889	2.99 +	0.25	0.66 +	3.28	1.21	7.47	4.57	1.98	2.50	3.32	3.44	1.62	32.28
1890	2.16	1.45	2.16	2.20	5.49	5.26	1.07	4.34	5.81	4.54	2.40	......	36.88
1891	1.44	1.57	3.25	1.63	0.49	4.31	3.52	3.16	0.47	2.65	0.74	3.29	27.52
1892	0.57	0.88	0.55	0.67	4.04	3.95	1.89	4.77	1.12	1.34	1.67	0.72	23.17
1893	1.62	3.71	1.94	2.59	4.92	3.08	3.68	5.38	2.68	1.59	1.09	1.56	33.84
1894	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.64	3.59	0.43	0.47	29.36
1895	0.96	......	0.29	1.36	2.88	......	......	2.66	0.94	0.72	2.31	2.49	......
1896	1.19	2.28	0.84	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	27.61
1897	0.64	0.21	2.12	1.90	2.19	3.16	5.28	1.27	2.36	0.73	2.53	1.39	23.78
1898	1.74	0.33	1.54	2.03	1.90	2.37	1.32	3.60	1.86	3.83	2.03	0.33	22.90
1899	0.37	0.30	1.22	1.12	1.69	1.71	4.15	1.05	2.23	2.69	1.36	1.46	19.35
1900	1.43	2.42	0.02	0.95	1.71	1.45	6.53	1.75	0.91	3.65	6.13	0.78	27.73
1901	0.72	......	2.19	4.43	3.80	2.07	3.97	5.52	2.46	1.35	2.09	3.37	31.97
1902	0.86	0.66	1.94	1.92	2.84	4.33	5.29	2.41	2.88	2.32	0.74	0.74	26.89
1903	1.81	1.11	5.62	2.60	0.23	7.77	4.86	7.21	1.30	4.19	1.63	0.38	38.69
1904	0.80	1.03	2.41	1.67	4.04	3.37	5.73	2.56	3.26	2.06	0.26	1.42	28.61
1905	0.40	0.27	1.09	2.05	2.01	8.78	3.59	5.44	1.90	3.69	1.32	1.84	32.38
1906	1.46	0.53	1.60	2.08	4.24	5.31	2.37	3.68	2.16	3.56	1.40	1.54	29.93
1907	1.89	0.03	1.14	2.42	1.82	2.34	2.86	1.35	2.73	3.48	2.78	1.89	24.73
1908	0.68	1.12	1.24	3.28	3.57	1.96	4.72	1.79	1.66	2.73	0.88	0.43	24.06

INDE

A.

Acid and coloring matter in gluten feeds. .
soil injurious in alfalfa culture. . . . . . .
Administration building, new, needed. . . . .
Adulteration in alfalfa seed. . . . .
of alfalfa seed—damages awarde
Agriculture, appropriations for. . . . .
Air, temperature readings. . . . .
Alderman, Wm. H., appointment as Assista
Alfalfa anthrachnose, discussion. . . . .
as a farm crop in New York. . . . . . .
bundle blackening in tap root. . . . . .
damping off of seedlings. . . . .
difficulties in culture. . . . .
diseases not known in New York, lis
downy mildew of. . . . .
failure of seed crop. . . . .
fungus diseases of. . . . .
growing, inoculation in. . . . .
impure and adulterated seed. . . . . . .
inoculation, artificial, need of. . . . . . .
by use of soil. . . . .
experiments, location. . .
plan. . . .
for. . . . .
natural source. . . . .
through seed. . . . .
leaf spot, discussion of. . . . .
leaf spots of:
Ascochyta, 225; Stagonospora, 22
dopeziza medicaginis, 216.
leaves, frost blisters on. . . . .
methods for supplying inoculation. . .
multiple-leaved. . . . .
nodules, appearance. . . . .
how to find. . . . .
presence in uninoculated fields
pitting of tap root. . . . .
prevalence of natural inoculation. . . .
root knot disease. . . . .
rot, discussion of. . . . .
roots and tile drains. . . . .

Alfalfa—(Continued): PAGE
saprophytic fungi on 236
seed, Alternaria disease of 228
damages awarded for adulteration 190
free analyses by Station 191
sifting to remove dodder 193
spontaneous combustion 236
troubles, bibliography of 239
investigation 172
summary of bulletin 17
unifoliate-leaved 238
viability of seed 183
white-flowered 239
white spot of 231
wilt, discussion of 218
winter injury of 182
yellow top 232
Alternaria disease of alfalfa seed 228
effect on fruit in cold storage 126, 127, 128, 129, 130, 131
Anaphothrips striata, connection with silver top of June grass 148
Andover, potato spraying experiment at 256
Anthrachnose, alfalfa. (See Alfalfa anthrachnose.)
Apple injury by sulphur fumigation 137
orchards, control of leaf blister-mite in 369
control of San José scale in 309
rot fungi, destruction by sulphur fumigation 135
rots in cold storage, investigation 124
scab, growth under bordeaux mixture 138
trees, effect of dipping on 349, 350, 351, 352, 354, 356, 357
effect of spray treatment on 317, 318, 323, 328, 331
Apples, blooming data for 464
early and late blooming varieties 448
Appropriations 8
for Agriculture 9
desired 8
Ascochyta leaf spot of Alfalfa 225
Assistant Horticulturist, appointment 7
resignation 7

B.

Bacteria, counting in cheese studies 60
found in cheese studied:
Cheese, 4.6I, 67; 4.6II, 71; 4.6III, 74; 4.6IV and 4.6V, 77; 4.6VII, 84; 4.6VIII, 89; 4.6IX, 95; 4.6X, 100.
in cheese, classification 62
nodule-forming, necessary in alfalfa culture 178
nomenclature for cheese study 115
occurrence and distribution in cheddar cheeses 113
Bacterial classification, key to 64
content, maximum in cheeses studied 107
of cheeses at various time intervals 107

Bacterial classification—Continued: PAGE
cultures in cheese studies, characteristics 116
flora of cheddar cheese 16
cheddar cheese, investigation 48
nine cheeses, qualitative summary 110
quantitative summary 104
studies, cheeses used in 54
of cheese, history 52
dilution of samples 56
media used 57
sampling cheese for 55
types in cheese, differentiation 60
cheeses studied:
Cheese, 4.6II, 71; 4.6III, 76; 4.6IV and 4.6V, 81; 4.6VII, 87; 4.6VIII, 93; 4.6IX, 98; 4.6X, 103.
Bacteriology, summary of work 15
Batavia, potato spraying experiment at 254
Bibliography of alfalfa troubles 239
Billings, P. C., co-operative potato spraying experiments by 263
Bitter-rot, effect of sulphur fumigation on 135
effect on fruit in cold storage 126, 127, 129, 130, 131
Black rot, effect of sulphur fumigation on 135
on fruit in cold storage 126, 127, 129, 130, 131
Blister-mite, control in apple orchards 21
Blooming data for fruit varieties 444
Blue mold, effect of sulphur fumigation on 135
on fruit in cold storage 126, 127, 128, 129, 130, 131
Booth, Nathaniel O., resignation as Assistant Horticulturist 7
Bordeaux-kerosene mixture, formula for 395
mixture, growth of apple scab under 138
Botany, summary of work in 16
Bradley, F. C. & L. B., co-operative potato spraying experiments by 257
Bradley, Wm. L., leaf blister mite experiment by 382
Brewster, potato spraying experiments at 264
Brown rot, effect of sulphur fumigation on 135
on fruit in cold storage 126, 127, 128, 129, 130, 131
Buckhorn. (See Plantain, narrow leaved).
Bud-rot, carnation, characteristics of 141
outbreak of 141
prevalence 143
Bulkley, H. L., leaf blister mite experiment by 381
Bulletins issued during 1908 23
noticed, No. 303, 518; 304, 518.
number distributed 10
reprinted, No. 296, 309; 297, 123; 298, 401; 299, 410; 300, 27; 301, 335; 302, 344; 305, 172; 306, 369; 307, 244; 308, 273; 309, 476; 310, 7.
Technical, reprinted, No. 7, 140; 8, 48.
Bur clover as an adulterant of alfalfa seed 189

C.

PAGE

Cabbage maggot, injury to seed beds by 337
seed beds, cost of screening 341
injury by insects 336
methods of protection 337
screening 20, 335
screening experiment 338
screening, suggestions 343
Carnation bud-rot, characteristics of 141
control of 168
fungus, inoculation experiments 155
prevalence 143
fungus, relation to mite 166
outbreak of 141
Carnations, Sporotrichum bud-rot of, investigation 140
notes on 18
Case, B. J., leaf blister-mite experiment by 378
Casein and fat, basis for payment 297
calculated, and fat, basis for payment 302
Cephalothecium roseum. (See Pink rot.)
Cercospora leaf spot of alfalfa 227
Cercospora medicaginis. (See Cercospora leaf spot.)
Chateaugay, potato spraying experiments at 261
Cheese, cheddar, bacterial flora of 16
investigation of bacterial flora 48
classification of bacteria in 62
cloth for screening cabbage seed beds 338
composition, relation to milk constituents 280
differentiation of bacterial types 60
factories, paying for milk at 18, 273, 289
from fat-rich milk, composition 234
normal milk, composition 281
skim milk, composition 282
history of bacterial studies 52
relation of composition and quality 285
samples for bacterial study, dilution 56
studies, characteristics of bacterial cultures in 116
counting bacteria in 60
media used in 57
yield and cheese solids, basis for payment 293
relation of fat in milk to 279
Cheeses, bacterial content at various time intervals 107
cheddar, occurence and distribution of bacteria in 113
maximum bacterial content 107
qualitative summary of bacterial flora 110
quantitative summary of bacterial flora 104
studied, germ content and physical condition:
Cheese, 4.6I, 69; 4.6II, 72; 4.6III, 75; 4.6IV and 4.6V, 79; 4.6VII, 85; 4.6VIII, 91; 4.6IX, 96, 4.6X, 101.
used in bacterial investigation, ... 54

PAGE

Cheeses used in bacterial investigation, detailed studies:
Cheese, 4.6I, 66; 4.6II, 71; 4.6III, 74; 4.6IV and 4.6V, 77; 4.6VII, 82; 4.6VIII, 88; 4.6IX, 94; 4.6X, 100.
Chemistry, summary of work in 18
Cherries, blooming data for 454
early and late blooming varieties 449
Circular reprinted, No. 9 388
Classification, bacterial, key to 64
of bacteria in cheese 62
Climate, changes in 443
Cloudiness data for May for 20 years 438
Cold storage, investigation of apple rots in 124
peach rot in 134
College of Agriculture, relations with 13
Colletotrichum trifolii. (See Alfalfa anthrachnose.)
Color, artificial, of gluten feeds 15
Commercial cultures for alfalfa inoculation 39
Cook, H. E., co-operative potato spraying experiments by 259
Cost of spray treatment for scale, summary 310
Counting bacteria in cheese studies 60
Crandall, M. A., & Son, co-operative potato spraying experiments by 256
Cuscuta. (See Dodder.)

D.

Dairymen, suggestions to 305
Daucus carota. (See Wild carrot.)
Davis, J. J., notes on carnation bud-rot 144
Denmark, potato spraying experiments at 259
Department of Botany, report 121
summary of work 16
Bacteriology, report 25
summary of work 15
Chemistry, report 271
summary of work 18
Entomology, report 307
summary of work 19
Horticulture, report 399
summary of work 22
Dianthus caryophyllus. (See Carnation.)
Differentiation of bacterial types in cheese 60
Diplodina medicaginis, occurrence on alfalfa 237
Dipping nursery stock 20, 344
Director's report 7
Diseases, fruit, investigations 123
Dodder, discussion of 196
general characteristics 196
host plants 198
importance 197

Dodder—(Continued): PAGE
in alfalfa seed 185
infested fields, appearance 198
methods of eradication 207
perennity 203
propagation and dissemination 200
re-seeding infested fields 210
seed, removal from alfalfa seed by sifting 193
seedlings, growth of 199
species 198
Donboro raspberry, description 408
Downy mildew of alfalfa 224
Drains, tile, and alfalfa roots 239
Dutton, A. H., co-operative spraying experiments by 313

E.

East Syracuse, potato spraying experiment at 257
Edmunds, Wm. J., leaf blister-mite experiment by 381
Emulsion, oil, for spring use 393
for summer use 394
formula for 393
Entomology, report of work in 307
summary of work in 19
Eustace, H. J., bulletin by 123

F.

Fat and calculated casein basis for payment 302
casein basis for payment 297
basis for milk payment 291
in milk, relation to cheese yield 279
plus-two method for payment 294
Feeding stuffs, summary of inspection 14
Feeds, adulteration with oat hulls 15
molasses, weed seeds in 15
Fertilizers, commercial, summary of inspection 13
Flea beetles, injury to cabbage seed beds 336
Foxtail in alfalfa seed 187
Fraser, S., co-operative potato spraying experiment by 255
French, G. T., bulletin by 172, 244
Frost blisters on alfalfa leaves 229
killing, and fruit setting 417
Frosts, killing, dates of for 20 years 424
Fruit disease investigations 123
early and late blooming varieties 448
setting and killing frosts 417
and rain 425
sunshine 434
temperature 429
wind 435
relation of weather to 22, 410
stored at moderate temperatures, effect of rot on 133

PAGE
Fruits, temperatures injurious to setting 418
Fumigation, sulphur, apple injury by 137
to destroy rot fungi 135
Fungus diseases of alfalfa 216

G.

Garrett, M. W., co-operative potato spraying experiments by 257
Geneseo, potato spraying experiment at 255
Glomerella rufomaculans. (See Bitter rot.)
Gluten feeds, coloring matter and acid in 15
Graduate School of Agriculture, meeting of 13
Grapes, blooming data for 471
Green, E. C., leaf blister-mite experiment by 372
Greenwich, potato spraying experiments at 263

H.

Hallock, Henry A., co-operative potato spraying experiments by 265
Harding, H. A., bulletins by 27, 48
Hardpan injurious in alfalfa culture 177
Hayt, E. F., co-operative potato spraying experiments by 264
Heald, F. D., discussion of article by 169
Heaving destructive to alfalfa 177
Hedrick, U. P., bulletin by 401, 410
Herrington, Chas. I., leaf blister-mite experiment by 383
Hodgkiss, H. E., bulletins by 140, 309, 344
Home made miscible oils 396
Horticultural Department, report 399
Horticulture, summary of work in 22
Houses, new, completion 11
Humus desirable in alfalfa culture 178

I.

Impurities in alfalfa seed 185
Inoculation, alfalfa, through seed 40
experiment with mites 165
experiments with alfalfa, location 35
plan 33
carnation bud-rot fungus 155
for alfalfa 15
methods for supplying 39
need of 38
in alfalfa growing 27
legume, historical 29
natural, for alfalfa, prevalence 35
source 37
of alfalfa by use of soil 42
Insects, injury to cabbage seed beds 336
Inspection work, summary of 13
Interlaken, potato spraying experiment at 257

J.

PAGE
Jamesport, potato spraying experiments at 265
Jordan, W. H., report as Director 7
June grass, silver top, investigation 140
notes on 147

K.

Kettle outfit for cooking spray mixtures 390

L.

Lafler, Wm. A., leaf blister-mite experiment by 374
Leaf blister-mite, control in apple orchards 369
experiments, 373, 374, 375, 376, 378, 379, 380
381, 382, 383
directions for applying sulphur wash 387
distribution as apple pest 370
economic importance 370
effect on crop yields 371
experiments in controlling:
At Station, 372; at Victor, 373; at Albion, 374; at Seneca, 375.
volunteer experiments:
At Old Chatham, 378; Penn Yan, 378; Sodus, 378; Pulteneyville, 379; Canandaigua, 380; Pulteney, 380; Sweden, 381; Le Roy, 382; Warsaw, 383; Pavilion, 382.
spot, alfalfa. (See Alfalfa leaf spot.)
Legume inoculation, historical 29
Lime-sulphur-soda wash, formula for 392
wash, commercial preparations of 386
dipping nursery stock in 344
formula 388
time of application 388
Louboro raspberry, description 407

M.

MacPherson, Roy P., leaf blister-mite experiment by 382
Magnus strawberry, description 405
Mailing list, number of names 10
Maintenance fund 7
Marlative raspberry, description 408
Marldon raspberry, description 408
Media used in bacterial study of cheese 57
Medicago hispida and *Medicago arabica*. (See Bur clover.)
lupulina. (See Yellow trefoil.)
Melilotus alba. (See Sweet clover.)
Meteorological data for 1908 527
Methods of paying for milk at cheese factories, discussion 273

Milk constituents and cheese composi
methods of payment for, at chees
payment for at cheese factories.
relation of fat in, to cheese yield
Miscible oils, home made...........
proprietary...........
Mite associated with carnation bud-r
leaf blister. (See Leaf blister m
relation to carnation bud-rot fu
Mites, inoculation experiment with..
Molasses feeds, weed seeds in.......

N

Narrow leaved plantain seed, removal
Nebraska Station Bulletin No. 103, di
Nematodes on alfalfa................
New York College of Agriculture, rela
Niagara County orchard spraying exp

Nodules on alfalfa, appearance.......
in uninoculated fie
Nomenclature, system of, for bacteria
Nursery stock, dipping.............

O

Oat hulls in feeds...................
Ogdensburg, potato spraying experime
O'Hanlon, Wm., report as treasurer..
Oil emulsion for spring use...........
summer use..........
formula for............
Oils, home made, miscible...........
proprietary, miscible............
Ontario County orchard spraying expe

Orchard spraying experiments, cost...
methoc
plants, description a
Orchards, control of blister-mite in....
scale in.........
cost of spray treatment for s
old, thinning and pruning...
Outfits for cooking sulphur wash......

P

Pardy Bros., co-operative potato spray
Parrott, P. J., bulletins by...........
circular by...........

PAGE

Peach rot in cold storage........ 134
trees, effect of dipping on........ 362
Peaches, blooming data for........ 451
early and late blooming varieties........ 449
Pear trees, effect of dipping on........ 350, 357, 360
Pears, blooming data for........ 461
early and late blooming varieties........ 449
Pediculoides dianthophilus (synonym of *Pediculopsis graminum*).
graminum, associated with carnation bud-rot........ 159
description and life history........ 161
food plants and injury by........ 164
geographical distribution........ 163
history of........ 159
systematic position of........ 160
Pegomya brassicae. (See Cabbage maggot.)
fusciceps. (See Cabbage maggot).
Penicillium glaucum. (See Blue mold.)
Periodicals received by Station........ 521
Peronospora trifoliorum. (See Alfalfa downy mildew.)
Phyllotreta vittata. (See Flea beetle.)
Pink rot, effect of sulphur fumigation on........ 135
on fruit in cold storage........ 126, 127, 128, 129, 130, 131
Plant breeding work, Station, purposes........ 402
Plantago lanceolata. (See Plantain.)
Plantain, English. (See Plantain, narrow leaved.)
narrow leaved, in alfalfa seed........ 187
Plattsburg, potato spraying experiment at........ 262
Plum trees, effect of dipping on........ 361
Plums, blooming data for........ 456
early and late blooming varieties........ 450
Poa pratensis. (See June grass.)
Potato spraying experiments........ 244
farmers' business series, details........ 253
summaries of........ 16, 245, 253, 267, 270
ten year series, details........ 249
volunteer series, details........ 269
Pratt, H. C., leaf blister-mite experiment by........ 380
Precipitation, monthly........ 537
Prole, G. A., co-operative potato spraying experiments by........ 254
Prolific strawberry, description........ 405
Prucha, M. J., bulletin by........ 48
Pseudomonas radicicola. (See Alfalfa inoculation.)
Pseudopeziza medicaginis. (See Afalfa leaf spot.)
Publications, station, list for 1908........ 23
Pythium de baryanum on alfalfa seedlings........ 222

Q.

Quality strawberry, description........ 406

R.

Rain and fruit setting....................
Rainfall for May for 20 years............
monthly........................
Raspberries and strawberries, Station seedl
Rathbun, F. G., co-operative potato sprayi
Repairs necessary......................
Report of Department of Bacteriology....
Botany.........
Chemistry......
Entomology....
Horticulture....
Director.....................
Treasurer....................
Reuter, Enzio, identification of carnation bı
Rhizoctonia. (See Alfalfa root-rot).
Rhizopus, effect of sulphur fumigation on...
Rice, C. Willard, leaf blister-mite experimen
Roesel, Paul, co-operative potato spraying e
Root injuries by immersion in spray mixtur
knot of alfalfa......................
rot of alfalfa, discussion of...........
Rot, peach. (See Peach rot.)
Rots, apple, in cold storage, investigation..
effect on fruit stored at moderate tem
Russian thistle in alfalfa seed.............

S.

Sagaponack, potato spraying experiments at
Salsola kali tenuifolia. (See Russian thistle.
Sampling cheese for bacterial studies......
San José scale. (See Scale, San José.)
Saprophytic fungi on alfalfa..............
Scab, effect on fruit in cold storage ....
Scale, control in apple orchards............
cost of spray treatment..............
San José, effect of dipping nursery sto
various sprays on..
remedies for..............
Schoene, W. J., bulletins by...............
Sclerotinia fructigena. (See Brown rot and I
libertiana. (See Alfalfa wilt.)
Screening cabbage seed beds...............
cost..........
suggestions....
Seed, alfalfa, free analyses by station.......
impure and adulterated.......
viability....................
beds, cabbage, screening............

Setaria glauca and *Setaria viridis*. (See Foxtail.) PAGE
Sifting alfalfa seed.. 193
Silver top of June grass...140, 147
Sirrine, F. A., bulletin by... 244
Smith, Oliver, & Son, co-operative potato spraying experiments by.... 261
Soil inoculation for alfalfa.. 42
troubles in alfalfa culture:
Poor fitting, 175; acidity, 176; excessive moisture, 176; heaving, 177; hardpan, 177; deficiency of humus, 178; deficiency of bacteria, 178
Sphaeropsis malorum. (See Black rot.)
Sporotrichum anthophilum, name given.................................. 142
(See Carnation bud-rot.)
bud-rot of carnations, investigation.................... 140
bud-rot of carnations, notes on......................... 18
poae, named.. 149
S. anthophilum and Heald's *Fusarium*, relationship., 150
Spray mixtures, injury to roots by dipping in........................ 365
treatments, effect on apple trees..............317, 318, 323, 328 331
effect on San José scale...........317, 318, 323, 328 331
Spraying experiments in orchards, methods............................ 313
with potatoes.. 244
summary of....................................... 16
Staff, Station, changes in.. 7
Stagonospora carpathica. (See Stagonospora leaf spot.)
leaf spot of alfalfa..................................... 226
Station staff, changes in.. 7
Station raspberries, description of varieties......................... 407
origination of varieties.......................... 406
strawberries, description of varieties....................... 405
origination of varieties....................... 403
Steam cooking outfit for making spray mixtures........................ 390
Stewart, F. C., bulletins by...............................140, 172, 244
Stoddard, H. W., leaf blister-mite experiment by...................... 379
Strawberries and raspberries, Station seedlings....................22, 401
cultural directions...................................476, 513
description of varieties................................ 483
(Varieties alphabetically arranged.)
desirable varieties..................................... 483
early and late bloomers................................. 482
early and late season................................... 480
good and poor plant makers.............................. 479
holding size well....................................... 481
notes on varieties...................................... 479
productive and unproductive............................. 481
summary of bulletin on.................................. 23
variety test.. 476
Strawberry, fertilizers for... 514
preparation of ground for............................... 513
seasonal treatment...................................... 516

Strawberry—(Continued): PAGE
selection of varieties and plants....514, 515
soil for.... 513
Sulphur fumigation, apple injury by.... 137
to destroy apple rot fungi.... 135
sprays, directions for use.... 385
formulas.... 385
wash, commercial preparations of.... 386
handling.... 392
orchard pests controlled by.... 391
outfits for cooking.... 389
Sunshine and fruit setting.... 434
Sweet clover as an adulterant of alfalfa seed.... 189
Systena hudsonias. (See Flea beetle.)

T.

Taylor, C. E., leaf blister-mite experiment by.... 380
O. M., bulletins by....401, 476
Temperature and fruit setting.... 429
daily range, and fruit setting.... 431
Temperatures, air, readings....527, 528, 531
average monthly and yearly.... 532
greatest daily range for May for 20 years.... 432
injurious to fruit setting.... 418
maximum and minimum....529, 530, 531
mean and extreme for May for 20 years.... 432
monthly maximum and minimum....533, 534, 535, 536
Thermometer, maximum and minimum, readings....529, 530, 531
standard air, readings....527, 528, 531
Treasurer's report.... 1
Trefoil, yellow. (See Yellow trefoil.)
Tuck, Andrew, co-operative potato spraying experiments by.... 260

V.

Van Slyke, L. L., bulletin by.... 273
Variety test of strawberries.... 476
Venturia inaequalis. (See Scab.)
Verona, potato spraying experiment at.... 258
Vincent, H. B., leaf blister-mite experiment by.... 378

W.

Weather and fruit setting, relation.... 410
observation stations, data for.... 440
relation to fruit setting.... 22
Weed seeds in molasses feeds.... 15
Weeds, importance in alfalfa culture.... 214
Weight of milk method for payment, discussion.... 290
Westchester County orchard spraying experiment....325, 327
Wet soil injurious in alfalfa culture.... 176

White, Floyd, co-operative orchard spraying experiment 325
spot of alfalfa 231
Wild carrot in alfalfa seed 187
Wilson, J. K., bulletins by 27, 172
Wilt, alfalfa, discussion of 218
Wind and fruit setting 435
direction for May for 20 years 438
Winter injury of alfalfa 182
Wolcott, Robt. H., discussion of article by 171
Wright, Berlin H., leaf blister-mite experiment by 378

Y.

Yellow top of alfalfa 232
trefoil as an adulterant of alfalfa seed 189
discussion of 211